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PENNSYLVANIA RAILROAD COMPANY

TEST DEPARTMENT

LOCOMOTIVE TESTING PLANT

AT

ALTOONA, PENNA.

TESTS OF [illegible] LOCOMOTIVE

[illegible]

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TESTS OF AN E2A LOCOMOTIVE

1910

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TESTS OF "E2A" ATLANTIC TYPE, SIMPLE LOCOMOTIVE.

PENNSYLVANIA RAILROAD COMPANY.

BULLETIN No. 5

The original program of tests that was planned by the Pennsylvania Railroad Company to be made on the Locomotive Testing Plant at St. Louis, in 1904, included tests of one of the Company's simple passenger locomotives of the Atlantic type with D valves* and a locomotive of this type was prepared and held in readiness for the tests, but as the time at St. Louis was not sufficient, these tests could not be carried out.

That tests of a simple two-cylinder passenger locomotive, made under the same conditions as were maintained in the tests of the four-cylinder balanced compound passenger locomotives, would be of particular interest has been apparent.

Upon the completion of the Testing Plant at its permanent location at Altoona this locomotive was placed upon it, and the Pennsylvania Railroad Company now makes public in the following pages the results of such a series of tests as was formerly contemplated.

This locomotive, No. 5266, has been tested by the same methods and under as nearly as possible the same conditions, using the same kind of coal as with the locomotives tested at St. Louis, so that comparisons are possible with these former tests. As the methods used in testing are given in detail in the report of the St. Louis tests, no extended description of them will be given here.

* See "Locomotive Tests and Exhibits," P. R. R., St. Louis, 1904.

Description of the Locomotive.

Locomotive No. 5266 is of the Atlantic type with two simple cylinders and is known as the "E2a" class. It is identical in all respects with the other locomotives of its class and may be taken as representative of a large class of passenger locomotives used on the Pennsylvania Railroad in regular service.

The locomotive was built in 1904 and has seen considerable service since that time. In preparing it for the tests it was taken into the shop and the boiler thoroughly cleaned and new tubes put in. New tires were put on the driving wheels to bring them up to the regular diameter of 80 inches. The machinery was thoroughly overhauled and put in good repair. The cylinders were found to be smooth and they were not rebored. The locomotive was then placed upon the plant and run for some time to get the bearing surfaces in good condition before beginning the tests.

Before the tests were completed the front driving wheel tires had become flat in one place, due, probably, to a soft place in the tire, and the locomotive was removed from the plant and the tires of the driving wheels turned.

The general dimensions of the locomotive are given below:

Total weight, in working order, lbs......	184,167
Weight on drivers, in working order, lbs..	110,001
Cylinders (simple) size inches..........	20½x26
Diameter of driving wheels, inches......	80
Fire-box heating surface, square feet.....	156.86
Heating surface of tubes (water side) square feet	2,471.04
Total heating surface (based on water side tubes), square feet...................	2,627.90
Total heating surface (based on fire side tubes), square feet...................	2,319.26
Grate area, square feet.................	55.5
Boiler pressure, lbs. per square inch......	205
Valves, type..........	Wilson double ported, slide
Valve gear	Stephenson
Fire-box, type..................	Wide, Belpaire
Number of tubes.....................	315
Outside diameter of tubes, inches........	2
Length of tubes, inches................	180

The maximum calculated tractive effort at starting is 22,500 pounds with 80 per cent. of the boiler pressure available as mean effective pressure in the cylinders. This is equal to 136.6 pounds per pound of mean effective pressure in the cylinders.

The ratio of weight on drivers to the calculated maximum tractive effort is 4.9 to 1.

General Arrangement of Locomotive.

Figure 918 shows the general arrangement of the locomotive and the location of the instruments used in testing.

Boiler.

The boiler, Figure 920, has no very unusual features; it is of the Belpaire type with a wide grate and sloping back head and throat sheet. The water spaces have been arranged with the idea of promoting good circulation. There is no brick arch, but there is what may be called a combustion chamber, though it is of small volume. This combustion space is increased by the dead grate at the front end of the grate. The feed water is delivered to the boiler through the back head, with an internal pipe to deliver it to the front end. There is no superheater or feed water heating device. The boiler is of steel throughout with plain tubes.

Smoke Box.

The arrangement of the draft appliances and netting in the smoke-box is shown in Figure 921.

The diaphragm is perforated and is fitted with the usual movable lower part. There is an inside stack reaching down nearly to the centre of the smoke-box. The exhaust nozzle is single and the tip is below the centre line of the smoke-box. The steam pipe, or branch pipe, is a single pipe in this locomotive in the centre of the smoke-box.

Neither the diaphragm nor the nozzle was changed during the series of tests.

Grate.

The grate is of the usual rocking finger type (see Figure 922) and can be shaken in four separate sections. At the front end there is a section of the grate without air inlets, or a "dead grate" about 18 inches wide. The grate is practically level. There is a drop grate section at both front and back of the fire-box. The active shaking part of the grate has an area of about 31 square feet, while the total area, including the whole space at the top of the grate up to the boiler sheets, is 55.5 square feet.

Soon after the tests were started it was found that with the damper in the ash-pan open the air inlet was not sufficiently large for tests of heavy load and the inlet area was increased by cutting holes in the ash-pan sides, so that the area of inlet for air was increased from 2.3 square feet to 6.3 square feet. This latter area was found to give not more than seven-tenths of an inch of water vacuum at full load tests.

It is probable that the area of opening in the ash-pan that is required on the Testing Plant, where the locomotive is stationary, is in excess of what would be necessary to give similar draught conditions where the locomotive is in service on the road, though data is not at hand to determine this.

The coal used in the tests of No. 5266 was the Scalp Level coal as used in the tests at St. Louis. The average analyses for the two series of tests are given below:

	St. Louis Tests.	Tests of No. 5266 at Altoona.
Fixed Carbon......	75.85 per cent.	76.25 per cent.
Volatile combustible.	16.25 " "	16.13 " "
Moisture	.9 " "	1.60 " "
Ash	7.00 " "	6.02 " "
	100.00 " "	100.00 " "
Sulphur determined separately	.90 " "	.94 " "
B. T. U. per pound of coal	15025	15143

In the following tables and plots the items of most general interest are given, while the complete records of the tests are shown in the appendix.

The conditions under which the tests were made were selected in the following manner: The reverse lever latch was placed in the notch which would give the least possible cut-off in the cylinders, and with fully opened throttle and constant speed a test was run. Then the reverse lever was advanced to the next notch, giving a longer cut-off and another test run. This increase of cut-off was continued until at this speed the boiler would fail to supply steam at approximately working pressure. This process was then repeated for the next higher speed. Thus the tests show the performance of the locomotive for almost its whole range of action. The higher power tests at each speed showing, with certain exceptions, the power that the locomotive is capable of delivering for a considerable length of time, such as two or three hours or the time required for a run over a 100-mile division of road.

This method of testing the locomotive under conditions which could be sustained for a considerable time, while it is the only fair method, does not, of course, give the much higher power that could be shown for a test of short duration, where the reserve power of a boiler full of heated water is drawn upon for a short time without using the injector to keep up the supply. It will be noted that in all of the tests that the injector was in operation practically all of the time of the test. (See item No. 226 in appendix.)

TESTS ON ATLANTIC TYPE, SIMPLE, LOCOMOTIVE NO. 5266.

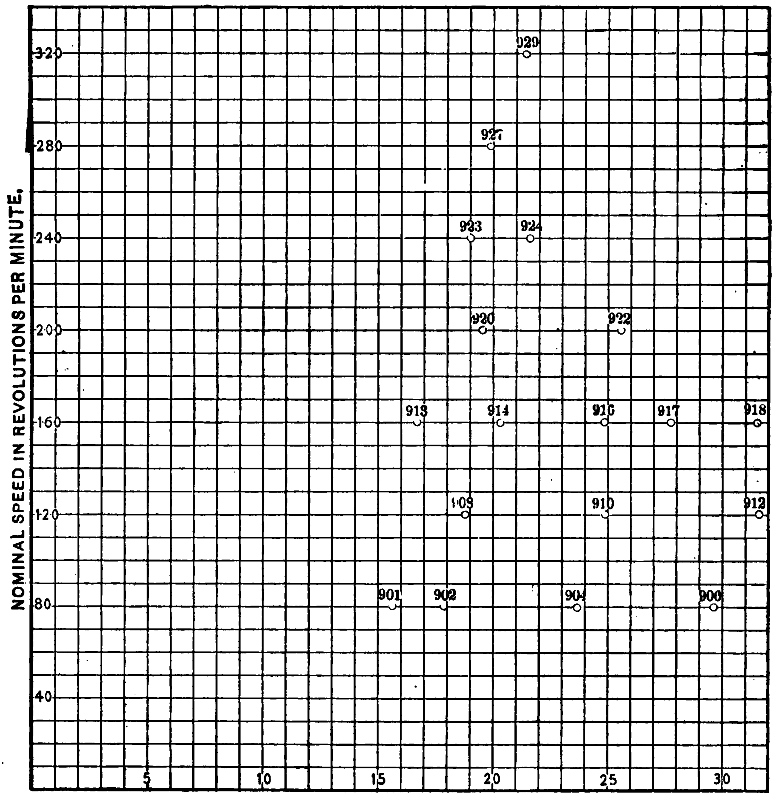


FIG. 901.

It has been the custom in locomotive tests to obtain a certain fixed evaporation for each square foot of heating surface or a certain quantity of coal burned per square foot of grate surface before ending the test, so that the total quantities would be approximately equal for tests at either light or heavy power.

While it cannot be said that any fixed method was rigidly adhered to in these tests, an endeavor was made to obtain an evaporation of 30 pounds of water for each square foot of heating surface or a total of approximately 70,000 pounds, though no tests were made of more than three hours duration. At speeds of 240 and 280 revolutions per minute many difficulties arise that limit the possibility of making successful tests, so rather than incur the risk of having to stop the locomotive with a test uncompleted, the time of these high speed tests was reduced to an hour or an hour and a half. As data throughout the full range of the boiler capacity can be determined at the intermediate speeds, there is little gained by running these high speed tests longer than is required to obtain enough readings to determine the performance of the engines of the locomotive and the draw-bar pull.

BOILER PERFORMANCE

GENERAL CONDITIONS—TABLE NO. 901.

The data for the tests in tables 901 to 908 inclusive are

TABLE No. 901—GENERAL BOILER CONDITIONS.

Identification of Test		Duration of Test, Minutes	Average Pressure Lbs. Per Sq. Inch		Av. Temp. Degrees F.		Total Coal Fired Per Sq. Ft. of Grate, Lbs.
Test Number	Laboratory Designation		Boiler Pressure	Atmospheric Pressure	Testing Plant	Feed Water	
		(Cal)	(217)	(221)	(208)	(211)	(Cal)
901	80-15-F	180	201.3	14.06	61.0	48.0	92.5
902	80-20-F	180	200.1	14.16	64.0	46.4	105.8
904	80-25-F	180	198.5	14.19	65.0	48.0	118.9
908	120-20-F	180	201.0	14.06	69.3	48.5	134.1
913	160-15-F	180	198.0	14.24	60.0	45.2	151.6
914	160-20-F	180	202.9	14.30	55.5	43.7	166.6
906	80-30-F	180	202.6	14.15	59.0	40.0	160.3
910	120-25-F	180	200.5	14.12	61.8	47.6	182.2
920	200-20-F	150	202.0	14.12	53.0	42.6	171.1
916	160-25-F	150	200.0	14.37	46.5	42.2	195.5
923	240-15-F	90	196.4	13.97	60.5	40.8	138.8
912	120-30-F	150	202.7	14.10	64.0	42.2	182.1
917	160-27-F	180	188.4	14.15	60.0	46.8	262.3
924	240-20-F	60	197.5	14.04	61.0	40.5	111.2
927	280-15-F	60	194.4	14.03	51.5	41.0	91.3
922	200-25-F	72	202.1	14.30	54.0	41.8	109.2
918	160-30-F	60	186.1	14.11	61.5	50.1	101.6

arranged according to the equivalent evaporation per hour (item 344, table No. 902), as this is a convenient index of the rate at which the boiler is working. The average steam pressure (item 217) can best be studied by reference to the graphical logs of the tests where the variations in pressure at each 10-minute interval are shown. The pressure reading was obtained by means of a sensitive gage mounted near the locomotive and connected to it by a flexible pipe. The gage has been found to give better service in this position than when mounted on the locomotive and exposed to the heat of the boiler. A correction was made in the gage reading for the head of condensed steam in the gage connection pipe.

As indicated in column 211, the feed water temperature was, at times, as low as 40° F, making a difference between the actual weight of water evaporated per hour and the equivalent evaporation of as much as 4,983 pounds.

The last column of table 901 gives the total coal per square foot of grate for the whole time of the test. In two tests only, the quantity is below 100 pounds.

EVAPORATION—TABLE 902.

This table shows the rates at which the boiler delivered steam to the engines, and it also shows the range of this delivery and the practical limitations upon the boiler capacity. Starting with an evaporation of 14,673 pounds per hour, the rates per hour advance by fairly even stages until an evaporation of about 30,000 pounds is reached. Where an evaporation of 30,721 pounds per hour is shown in test 918 the steam pressure, as shown by the graphical log for this test, could not be maintained and the upper limit of boiler delivery was exceeded in this test. The boiler may be expected to deliver a maximum of 30,000 pounds of steam per hour with this coal and these draught arrangements. The quality of the steam does not vary greatly from a mean of about 98.5 per cent., or practically dry steam, and the results do not indicate that a greater amount of moisture is present in the steam when the boiler is delivering large quantities of steam than when the evaporation is low.

TABLE No. 902—EVAPORATION.

Identification of Test		Duration of Test, Minutes	Water and Steam		Calorimeter Results			Equivalent Evaporation, Lbs. Per Hour
Test Number	Laboratory Designation		Total Lbs. Evaporated	Pounds Evaporated Per Hour	Quality Steam in Dome	Quality Steam in Branch Pipe	Degrees Superheat Branch Pipe	
		(Cal)	(264)	(340)	(228)	(229)	(230)	(344)
901	80-15-F	180	44020	14673	.9856	.9983	0	17806
902	80-20-F	180	48226	16075	.9866	.9997	0	19546
904	80-25-F	180	55536	18512	.9860	1.0022	4.00	22466
908	120-20-F	180	60406	20135	.9860	1.0024	4.20	24434
913	160-15-F	180	62276	20759	.9864	1.0055	9.60	25259
914	160-20-F	180	66120	22040	.9854	1.0067	11.72	26851
906	80-30-F	180	67608	22536	.9845	.9994	0	27519
910	120-25-F	180	70001	23334	.9860	1.0069	12.08	28330
920	200-20-F	150	65283	26113	.9856	1.0098	17.16	31841
916	160-25-F	150	66090	26436	.9859	1.0106	18.57	32246
923	240-15-F	90	41048	27365	.9850	1.0091	15.93	33383
912	120-30-F	150	69273	27711	.9851	1.0071	12.43	33792
917	160-27-F	180	86010	28670	.9860	1.0202	35.51	34793
924	240-20-F	60	28670	28670	.9860	1.0093	16.29	35014
927	280-15-F	60	28890	28890	.9854	1.0084	14.73	35240
922	200-25-F	72	36360	30300	.9859	1.0127	22.23	36981
918	160-30-F	60	30721	30721	.9860	1.0218	38.38	37170

Boiler Power—Table 903.

The boiler horse-power (item 349) is based upon the generally accepted unit of an equivalent evaporation of 34.5 pounds of water per hour for each boiler horse-power. The range of the tests is from about 500 to 1,000 boiler horse-power. This table shows that the boiler will deliver about 1,000 boiler horse-power, which is at the rate of about .43 of a horse-power per square foot of heating surface, or 2.32 square feet of heating surface per horse-power. There is about 18 horse-power delivered per square foot of grate surface.

TABLE No. 903—BOILER POWER.

Identification of Test		Duration of Test, Minutes	Equivalent Evaporation, Lbs.		Boiler Horse-Power		
Test Number	Laboratory Designation		Per Sq. Ft. of Grate Surface Per Hour	Per Sq. Ft. of Heating Surface Per Hour	Total	Per Sq. Ft. Heating Surface	Per Sq. Ft. Grate Surface
		(Cal)	(Cal)	(345)	(349)	(Cal)	(Cal)
901	80-15-F	180	321	7.68	516.0	.222	9.30
902	80-20-F	180	352	8.43	566.6	.244	10.21
904	80-25-F	180	405	9.69	651.1	.281	11.73
908	120-20-F	180	440	10.54	708.2	.305	12.76
913	160-15-F	180	455	10.89	732.1	.316	13.19
914	160-20-F	180	484	11.58	778.3	.336	14.02
906	80-30-F	180	496	11.87	797.7	.344	14.37
910	120-25-F	180	510	12.21	821.2	.354	14.80
920	200-20-F	150	574	13.73	922.9	.398	16.63
916	160-25-F	150	581	13.90	934.7	.403	16.84
923	240-15-F	90	602	14.39	967.6	.417	17.43
912	120-30-F	150	609	14.68	979.4	.422	17.65
917	160-27-F	180	627	15.00	1008.5	.435	18.17
924	240-20-F	60	631	15.10	1014.9	.438	18.29
927	280-15-F	60	635	15.19	1021.4	.440	18.40
922	200-25-F	72	666	15.94	1071.9	.462	19.31
918	160-30-F	60	670	16.03	1077.4	.465	19.41

Coal and Rate of Combustion—Table 904.

The coal fired per hour ranges from 1,665 to 6,101, but it does not follow exactly the increase in evaporation. This can be accounted for principally as due to variation in estimating the depth of fire at the beginning and end of the test, and the inconsistencies are most marked in the tests of short duration. From observation and as indicated on the graphical logs, the rate of firing was as uniform as can be expected.

TABLE No. 904—COAL AND RATE OF COMBUSTION.

Identification of Test				Fuel In Pounds			Rate of Combustion	
Test Number	Laboratory Designation	Duration of Test, Minutes	Total Dry Coal Fired	Total Combustible By Analysis	Dry Coal Fired Per Hour	Combustible Fired Per Hour	Dry Coal Fired Per Sq. Ft. of Grate Per Hour	Dry Coal Per Sq. Ft. Heating Surface Per Hour
		(Cal)	(235)	(236)	(338)	(Cal)	(339)	(Cal)
901	80-15-F	180	4994	4723	1665	1574	30.00	.718
902	80-20-F	180	5802	5392	1934	1797	34.85	.834
904	80-25-F	180	6530	6140	2177	2047	39.23	.939
908	120-20-F	180	7365	6926	2455	2309	44.24	1.059
913	160-15-F	180	8186	7742	2729	2581	49.17	1.177
914	160-20-F	180	8995	8508	2998	2836	54.01	1.293
906	80-30-F	180	8797	8212	2932	2737	52.83	1.264
910	120-25-F	180	10000	9410	3333	3137	60.04	1.437
920	200-20-F	150	9235	8735	3694	3494	66.56	1.593
916	160-25-F	150	10552	9981	4221	3992	76.05	1.820
923	240-15-F	90	7620	7113	5080	4742	91.53	2.190
912	120-30-F	150	9970	9335	3988	3734	71.86	1.720
917	160-27-F	180	14405	13547	4802	4516	86.53	2.070
924	240-20-F	60	6101	5695	6101	5695	109.93	2.631
927	280-15-F	60	5012	4678	5012	4678	90.31	2.161
922	200-25-F	72	5980	5599	4983	4666	89.78	2.149
918	160-30-F	60	5581	5249	5581	5249	100.58	2.406

Cinders and Sparks—Table 905.

As the coal used in these tests was of a friable nature and as much of it was of very small size when fired, it is to be expected that the quantities of cinders and sparks will be large. In test 918, laboratory designation 160—30—F, the cinders caught in the smoke-box were 987 pounds, and this quantity was sufficient to fill the smoke-box, which is not of the self-cleaning design, so that the draft was obstructed and the boiler failure, which occurred in this test, is directly traceable to this cause.

The calorific value of the cinders and sparks is high. They represent practically unburned coal, and in view of the large quantities drawn through the tubes it is apparent that better results could be expected from burning this quantity of coal on a much larger grate where the draft action need not be so intense in order to burn the quantity of fuel required.

TABLE No. 905—CINDERS AND SPARKS.

Identification of Test		Duration of Test, Minutes	Total in Lbs. Per Hour			Calorific Value B. T. U. Per Lb.	
Test Number	Laboratory Designation		Cinders in Smoke-Box	Sparks from Stack	Cinders and Sparks	of Cinders	of Sparks
		(Cal)	(238)	(239)	(240)	(250)	(251)
901	80-15-F	180	52	16	68	11713	10868
902	80-20-F	180	46	10	56	10370	11784
904	80-25-F	180	82	16	98	12491	11784
908	120-20-F	180	101	23	124	10606	8484
913	160-15-F	180	98	43	141	12770	8910
914	160-20-F	180	194	47	241	11048	9860
906	80-30-F	180	66	47	113	11291	10065
910	120-25-F	180	236	15	251	11194	11017
920	200-20-F	150	204	85	289	9471	11378
916	160-25-F	150	302	128	430	9287	9042
923	240-15-F	90	508	84	592	10506	9299
912	120-30-F	150	110	153	263	11998	12057
917	160-27-F	180	492	140	632	9701	11617
924	240-20-F	60	514	95	609	12157	11977
927	280-15-F	60	584	58	642	11472	12197
922	200-25-F	72	316	208	524	11523	11198
918	160-30-F	60	987	238	1225	11497	10899

Draught and Rate of Combustion.

Smoke-Box and Fire-Box Temperatures—Table No. 906.

In this table are shown the results of the observations of the draught, and in Fig. 902 these draught results are plotted in connection with the amounts of coal burned. The figures show wide variations, and this is to be expected, as the draught is influenced by a number of factors, such as the thickness of the fire, the boiler pressure and by the position of the fire door. The readings are the average of readings taken at the beginning of each ten-minute interval without regard to whether the fire door was

TABLE No. 906—DRAUGHT, RATE OF COMBUSTION, SMOKE-BOX AND FIRE-BOX TEMPERTURES.

Identification of Test		Duration of Test, Minutes	Draught in Inches of Water				Temp. Degrees F.		Dry Coal Per Sq. Ft. Grate Surface, Per Hour, Lbs.
Test Number	Laboratory Designation		In Front of Diaphragm	Back of Diaphragm	In Fire-Box	In Ash-Pan	In Fire-Box	In Smoke-Box	
		(Cal)	(222)	(223)	(224)	(225)	(212)	(207)	(339)
901	80-15-F	180	2.0	1.8	.6	.2	1774	562	30.00
902	80-20-F	180	2.1	1.9	.8	.1	1918	579	34.85
904	120-20-F	180	3.3	3.1	1.4	.7	1803	618	39.23
908	160-15-F	180	3.9	3.4	1.7	.7	1859	644	44.24
914	160-20-F	180	3.1	2.8	.9	.2	2078	633	49.17
906	80-30-F	180	3.7	3.2	1.2	.2	1952	654	54.01
910	120-25-F	180	3.4	2.9	.7	.3	1915	630	52.83
920	200-20-F	180	5.1	4.5	2.3	1.0	1965	672	60.04
916	160-25-F	150	5.0	4.2	1.3	.2	2076	679	66.56
923	80-25-F	150	5.2	4.4	1.5	.3	1936	681	76.05
912	240-15-F	90	5.6	4.7	1.3	.2	2025	693	91.53
924	120-30-F	150	4.9	4.2	1.4	.3	2077	665	71.86
927	160-27-F	180	7.7	6.2	2.1	.3	2058	719	86.53
922	240-20-F	60	5.4	4.6	1.4	.3	2266	675	109.93
918	280-15-F	60	5.6	4.9	1.5	.2	2165	715	90.31
917	200-25-F	72	6.0	5.1	1.6	.3	2180	694	89.78
913	160-30-F	60	8.9	8.0	3.0	1.3	2143	740	100.58

open or not. As a matter of fact, in some of the heavier power tests the fire door is open more than one-half of the time, and as this is one of the fixed conditions governing the intensity of the draught, it has not been eliminated from the readings of the average draught.

Fire-box and smoke-box temperatures were measured by means of thermo couples.

Evaporative Performance—Table 907.

In Figure No. 905 the equivalent evaporation is plotted with the evaporation per square foot of heating surface. The equiva-

TABLE No. 907—EVAPORATIVE PERFORMANCE.

Identification of Test			Evaporative Performance				
Test Number	Laboratory Designation	Duration of Test, Minutes	Total Water Divided by Total Coal	Equivalent Evaporation Per Pound of Dry Coal	Equivalent Evaporation Per Pound of Combustible	B. T. U. Per Pound of Dry Coal	Efficiency of Boiler
		(Cal)	(Cal)	(347)	(348)	(248)	(350)
901	80-15-F	180	8.57	10.69	11.31	15264	67.65
902	80-20-F	180	8.21	10.11	10.88	15077	64.76
904	80-25-F	180	8.42	10.32	10.98	15167	65.71
908	120-20-F	180	8.12	9.95	10.58	15167	63.36
913	160-15-F	180	7.40	9.26	9.79	15264	58.59
914	160-20-F	180	7.15	8.96	9.46	15264	56.68
906	80-30-F	180	7.60	9.39	10.05	15020	60.38
910	120-25-F	180	6.92	8.50	9.03	15167	54.13
920	200-20-F	150	6.88	8.62	9.11	15264	54.52
916	160-25-F	150	6.09	7.64	8.08	15264	48.34
923	240-15-F	90	5.33	6.57	7.04	15020	42.25
912	120-30-F	150	6.85	8.47	9.05	15057	54.32
917	160-27-F	180	5.91	7.25	7.70	15167	46.17
924	240-20-F	60	4.65	5.74	5.15	15020	36.91
927	280-15-F	60	5.70	7.03	7.53	15020	45.20
922	200-25-F	72	6.00	7.42	7.93	15057	47.59
918	160-30-F	60	5.45	6.66	7.08	15167	42.41

lent evaporation per pound of coal ranges from 10.69—which is obtained at the lowest rate of evaporation, viz: 7.68 pounds per square foot of heating surface— to a minimum of 5.74. The highest rate of evaporation was 16.09 pounds per square foot of heating surface.

From the results in this table it is evident that the economical performance of the locomotive boiler is very creditable when compared with results obtained from stationary boilers. The rates of coal burning and evaporation for the locomotive begin at and extend beyond the maximum of the ordinary stationary boiler.

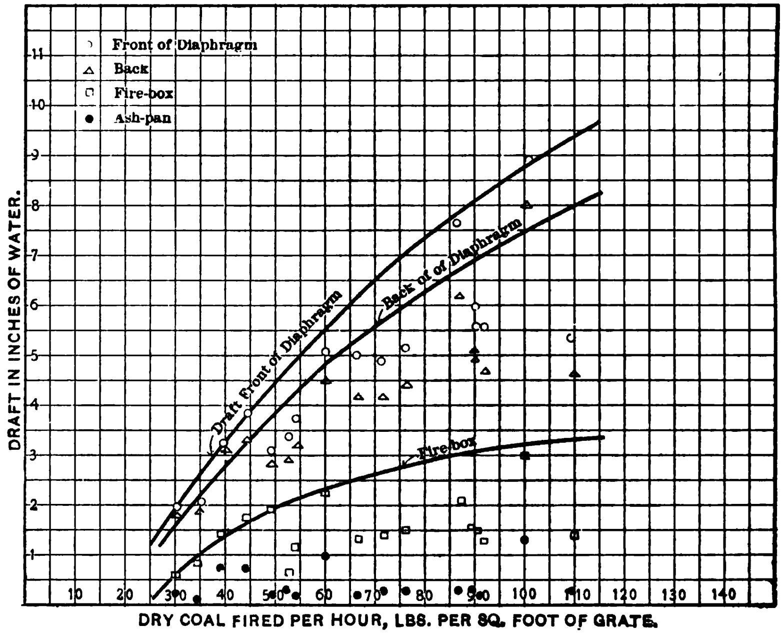


FIG. 902—DRAFT AND RATE OF COMBUSTION.

As shown in column 248, the calorific value of the dry coal in B. T. U.'s is very uniform for all of the tests. The determinations of heating value were made from samples taken from each car of coal used. These samples were taken from the coal conveyor as the coal was being placed in the testing plant coal bins.

The efficiency of the boiler, as given in column 350, is based upon the calorific value of the dry coal.

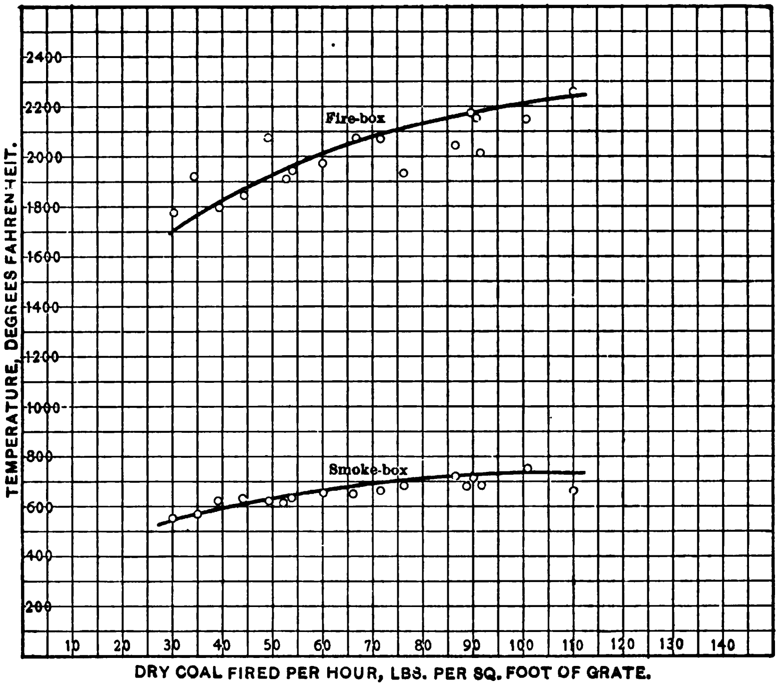


FIG. 903—FIRE-BOX AND SMOKE-BOX TEMPERATURES.

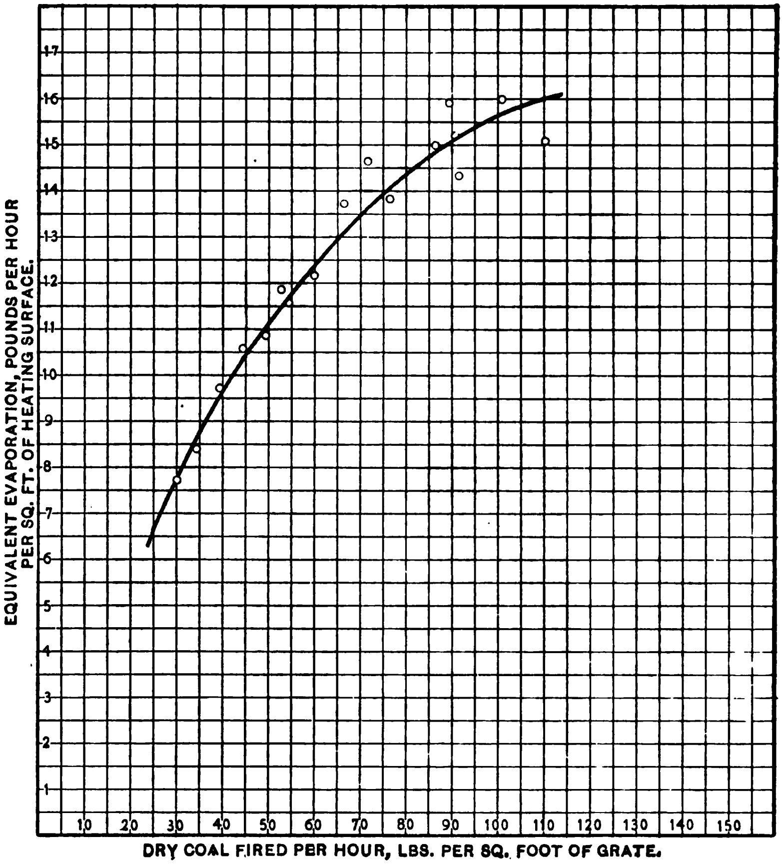


FIG 904—RATE OF COMBUSTION AND RATE OF EVAPORATION.

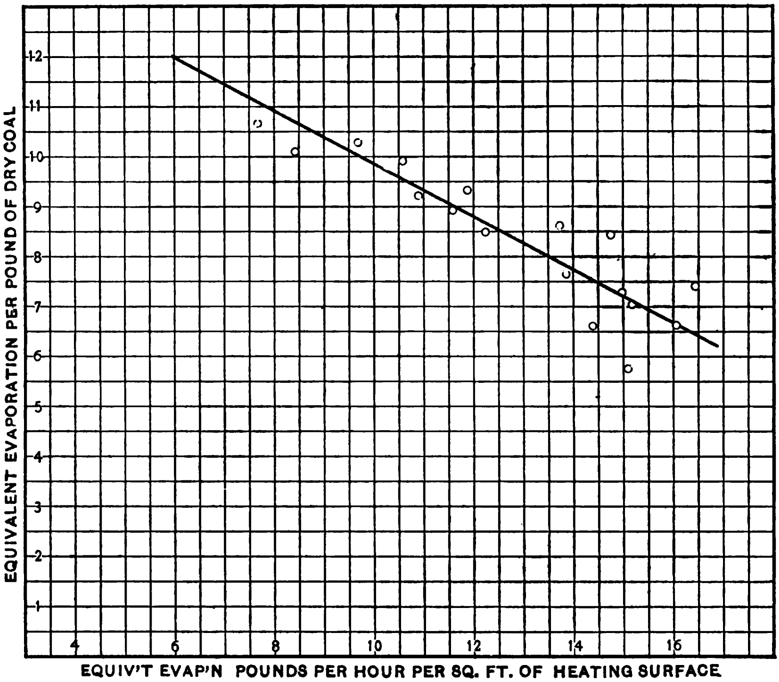


FIG. 905—RATE OF EVAPORATION AND EVAPORATION PER LB. OF COAL.

SMOKE-BOX GASES—TABLE 908.

The analysis of the smoke-box gases is of interest in showing the completeness of the combustion, and by reference to column 254 a very small percentage of carbon monoxide is shown

TABLE No. 908—SMOKE-BOX GASES.

Identification of Test		Duration of Test, Minutes	Analysis of Smoke-Box Gases				Calorific Value Coal as Fired	Per Cent. of Heat in Coal, Lost by Presence of CO
Test Number	Laboratory Designation		Per Cent. Oxygen O	Per Cent. Carbon Monoxide CO	Per Cent. Carbon Dioxide CO_2	Per Cent. Nitrogen N		
.		(Cal)	(253)	(254)	(255)	(256)	(Cal)	(Cal)
901	80-15-F	180	9.26	0	10.46	80.26	14849	0
902	80-20-F	180	8.40	0	10.67	80.93	14896	0
904	80-25-F	180	11.80	0	7.80	80.30	15009	0
908	120-20-F	180	8.70	0	10.50	80.80	15009	0
913	160-15-F	180	6.86	.13	12.20	80.80	14849	0.61
914	160-20-F	180	10.30	0	9.06	80.60	14849	0
906	80-30-F	180	8.53	0	9.67	81.80	14853	0
910	120-25-F	180	6.40	0	13.60	80.90	15009	0
920	200-20-F	150	9.13	.06	10.33	80.46	14849	0.33
916	160-25-F	150	9.73	.06	9.60	80.60	14849	0.36
923	240-15-F	90	5.20	1.60	11.00	82.20	14853	7.31
912	120-30-F	150	6.86	0	11.33	81.80	14853	0
917	160-27-F	180	2.60	.60	14.40	82.40	15009	2.28
924	240-20-F	60	6.40	.20	11.00	82.40	14853	1.03
927	280-15-F	60	5.60	2.00	10.60	81.80	14853	9.13
922	200-25-F	72	6.60	1.20	10.20	82.00	14853	6.06
918	160-30-F	60	4.70	.60	12.70	82.00	15009	2.57

in any of the tests and the losses in heat from the presence of CO, as shown in the last column of the table, are correspondingly small.

PERFORMANCE OF ENGINES

GENERAL ENGINE CONDITIONS—TABLE 909.

The tests in this and the following tables are arranged according to speed and cut-off, beginning with a speed of 80 revolutions per minute and a nominal cut-off of 15 per cent. The cut-off at 80 revolutions per minute was increased until it became evident that a further increase in cut-off would result in slipping the driving wheels, should the adhesion become momentarily reduced from any cause. The limit of the boiler to supply steam was not nearly reached at this speed, nor was it quite reached at 120 revolutions, though the evaporation at 120 revolutions per minute would indicate that it is close to the limit of boiler power. At 160 revolutions per minute, or 38.2 miles per hour, the boiler power limit was reached and exceeded, and for this and the higher speeds the danger of slipping was not a factor in limiting the cut-off used.

TABLE No. 909—GENERAL ENGINE CONDITIONS.

Identification of Test		Duration of Test, Minutes	Revolutions Per Minute	Speed, Miles Per Hour	Cut-off, Per Cent. of Stroke	Steam Pressure	
Test Number	Laboratory Designation					In Boiler, Lbs., Per Sq. Inch	In Branch Pipe, Lbs., Per Sq. Inch
		(Cal)	(198)	(199)	(268) to (271)	(217)	(220)
901	80-15-F	180	80.00	19.10	15.7	201.3	198.3
902	80-20-F	180	80.00	19.10	17.9	200.1	197.3
904	80-25-F	180	79.99	19.09	23.7	198.5	192.8
906	80-30-F	180	80.00	19.01	29.7	202.6	199.8
908	120-20-F	180	120.00	28.65	18.8	201.0	197.7
910	120-25-F	180	120.00	28.65	24.9	200.5	197.5
912	120-30-F	160	120.00	28.65	31.7	202.7	197.8
913	160-15-F	180	160.00	38.20	16.7	198.0	195.0
914	160-20-F	180	160.00	38.20	20.2	202.9	198.2
916	160-25-F	150	160.00	38.20	24.9	200.0	195.0
917	160-27-F	180	160.00	38.20	27.7	188.4	185.6
918	160-30-F	60	160.00	38.20	31.5	186.1	181.8
920	200-20-F	150	200.00	47.75	19.5	202.0	197.4
922	200-25-F	72	200.00	47.75	25.5	202.1	197.1
923	240-15-F	90	240.00	57.30	19.0	196.4	194.2
924	240-20-F	60	240.00	57.30	21.6	197.5	195.1
927	280-15-F	60	280.00	66.85	19.9	194.4	191.7
929	320-15-F	—	320.17	76.08	21.4	196.3	——

Test 929, at 320 revolutions per minute, was not made as one of the regular series in which all observations were recorded, but the locomotive was run for about 20 minutes at this speed and six indicator diagrams taken. The fore and aft vibration.

due to the unbalanced reciprocating weights, is so great at this speed that it was thought best not to subject the dynamometer to these violent shocks for a longer time. It is evident also from the draw-bar pull record obtained at this speed that the dynamometer, unless protected from the effect of these forces, cannot give a true indication of the draw-bar pull.

Between the dynamometer and the locomotive are placed oil dash-pots to absorb the vibrations which are present at all speeds, and for the lower speeds the dash-pots effectually control these unbalanced forces. If it were possible to run this locomotive at 320 revolutions with a cut-off of 25 or 30 per cent., it is probable that the action of the steam in the cylinders would assist the dash-pots in reducing these forces.

It has been found that if the throttle is suddenly closed at speeds of 280 or 320 revolutions, the vibrations set up are very violent in the absence of compression in the cylinders. The locomotive could not maintain the steam pressure, however, with the cut-off greater than about 15 per cent.

From an inspection of the diagram (Fig. 910) and table 909, (items 268-272), it is apparent that tests at different speeds, while run with the reverse lever in the same notch, do not have the same actual cut-off in the cylinders, but the cut-off point becomes later as the speed increases, due, probably, to a springing of the valve motion. This effect is so marked that the locomotive will run forward at the higher speeds with the reverse lever in one of the notches of the backward motion. As shown in table 909, the cut-off increases from 15.7 per cent. at 80 revolutions per minute to 21.4 per cent. at 320 revolutions per minute, while nominal cut-off or reverse lever notch remains the same.

Mean Effective Pressure, Indicated Horse-Power and Steam Consumption—Table 910.

The steam consumption decreases as the indicated horse-power increases, and while the best result is 23.81 pounds of dry steam per indicated horse-power hour, the minimum rate of which the engines are capable does not appear to have been reached before the limit of the boiler to supply steam had been found.

TABLE No. 910—MEAN EFFECTIVE PRESSURE, INDICATED HORSE-POWER AND STEAM CONSUMPTION.

Identification of Test		Duration of Test, Minutes	Mean Effective Pressure, Lbs. Per Sq. Inch	Indicated Horse-Power	Dry Steam Per Indicated Horse-Power Hour, Lbs.
Test Number	Laboratory Designation				
		(Cal)	(Cal)	(379)	(381)
901	80-15-F	180	60.56	419.8	33.54
902	80-20-F	180	68.81	477.2	32.27
904	80-25-F	180	84.47	585.6	30.65
906	80-30-F	180	104.91	727.9	29.94
908	120-20-F	180	66.13	687.6	28.81
910	120-25-F	180	81.83	851.1	26.70
912	120-30-F	150	97.63	1015.4	26.63
913	160-15-F	180	54.02	748.8	26.75
914	160-20-F	180	59.63	826.8	25.34
916	160-25-F	150	72.96	1011.6	25.23
917	160-27-F	180	76.04	1055.0	26.50
918	160-30-F	60	81.74	1133.4	26.46
920	200-20-F	150	58.78	1018.6	24.83
922	200-25-F	72	70.59	1223.7	23.84
923	240-15-F	90	52.18	1085.4	24.60
924	240-20-F	60	55.98	1164.5	24.37
927	280-15-F	60	48.56	1178.4	23.81
929	320-15-F	—	—	1281.3	—

It is to be noted that the highest sustained output of the boiler was 30,300 pounds of steam per hour and that this gives a maximum of 1,223.7 indicated horse-power. Unless a greater supply of steam than 30,300 pounds can be obtained from the boiler, the maximum horse-power will be about 1,200 without regard to the speed. Larger horse-powers in road service or on the testing plant may be obtained for short intervals as already noted.

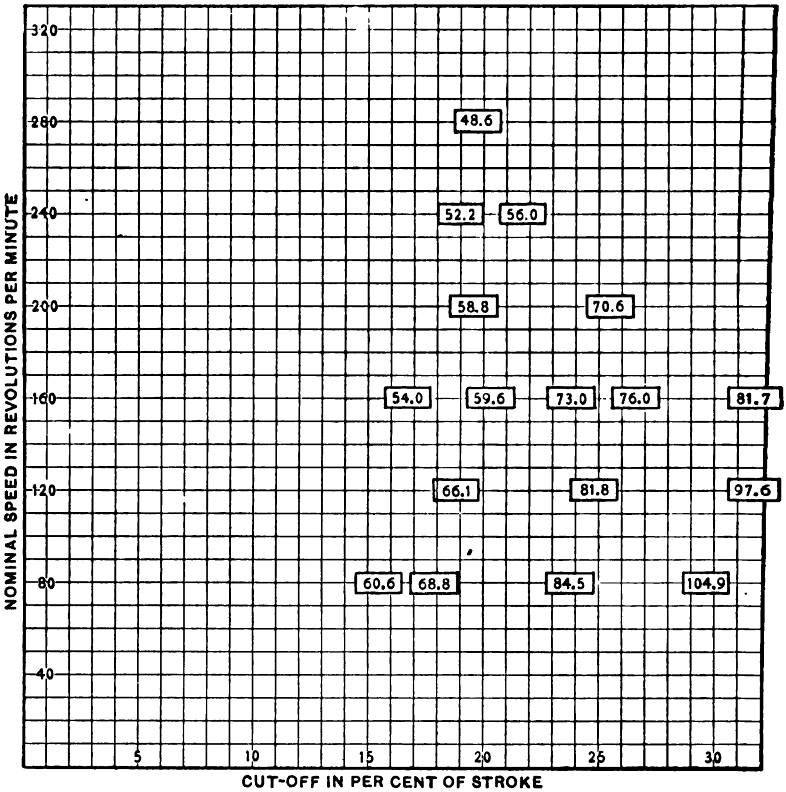


FIG. 906—MEAN EFFECTIVE PRESSURE.

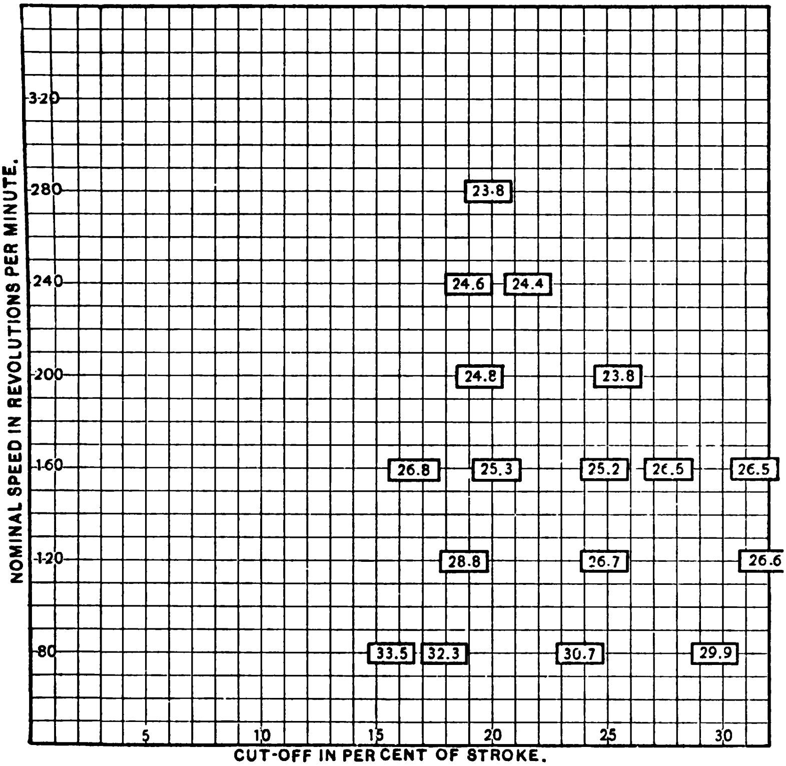


FIG. 907—DRY STEAM PER I. H. P. HOUR.

PERFORMANCE OF LOCOMOTIVES

DYNAMOMETER RECORDS—TABLE 911.

The draw-bar pull was measured by means of a lever dynamometer the details of which have been given in previous bulletins.

In the case of test 929, as explained in another place, the dynamometer reading was not correct, and the draw-bar pull and dynamometer horse-power for this test were derived from the indicated horse-power by assuming a machine efficiency of 70 per cent. for this speed.

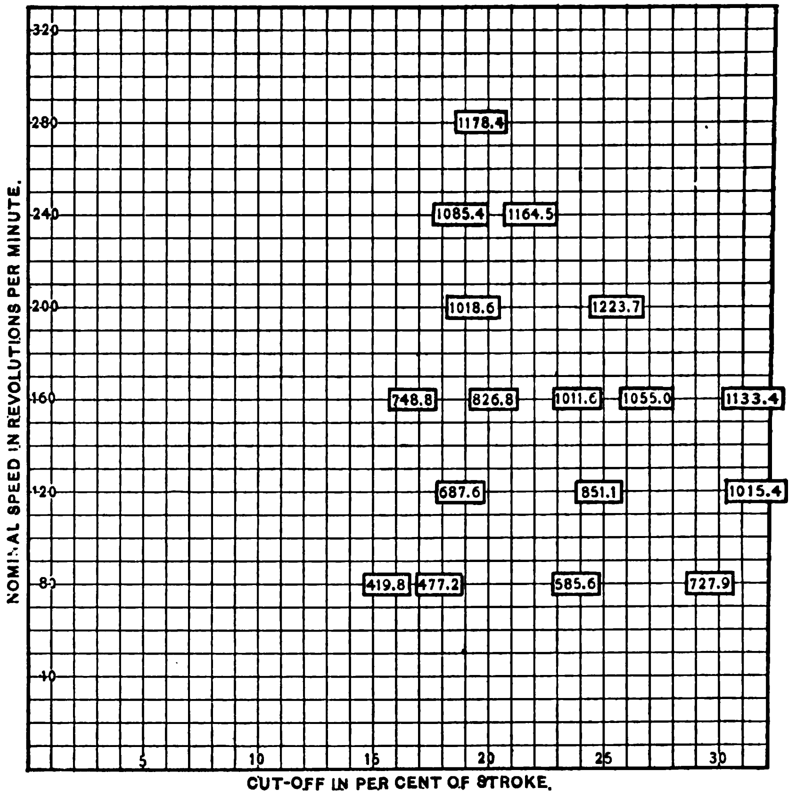


FIG. 908—TOTAL INDICATED HORSE POWER.

TABLE No. 911—DYNAMOMETER RECORDS.

Identification of Test: Test Number	Identification of Test: Laboratory Designation	Duration of Test, Minutes	Draw-bar Pull in Pounds	Dynamometer Horse-Power	Dry Coal Per D. H. P. Hour	Dry Steam Per D. H. P. Hour
		(Cal)	(265)	(383)	(384)	(385)
901	80-15-F	180	6427	327.3	5.09	43.02
902	80-20-F	180	7653	389.8	4.96	39.50
904	80-25-F	180	9810	499.6	4.36	35.92
906	80-30-F	180	12475	632.3	4.64	34.46
908	120-20-F	180	7280	556.2	4.42	35.16
910	120-25-F	180	9438	721.1	4.62	31.51
912	120-30-F	150	11785	900.8	4.43	29.59
913	160-15-F	180	5578	568.2	4.80	35.26
914	160-20-F	180	6538	665.9	4.50	31.46
916	160-25-F	150	8155	830.7	5.08	30.73
917	160-27-F	180	8757	892.1	5.38	31.34
918	160-30-F	60	9571	975.0	5.72	30.83
920	200-20-F	150	6199	789.4	4.68	32.04
922	200-25-F	72	7701	980.6	5.08	29.75
923	240-15-F	90	4940	880.7	5.77	30.31
924	240-20-F	60	5908	902.8	6.76	31.43
927	280-15-F	60	4752	847.2	5.92	33.12
929	320-15-F	—	*4424	*896.9	——	——

* Estimated.

The dry coal per dynamometer horse-power ranges from 4.42 pounds to 6.76.

MACHINE FRICTION—TABLE 912.

Throughout this series of tests the driving axle bearings were lubricated with oil. The main and side rods, except the front end of the main rods, were lubricated with hard grease. The cylinders were lubricated with oil by means of a sight feed lubricator.

The machine friction in draw-bar pull is a fairly uniform quantity, ranging from 1,417 to 1,909 pounds; in test 923 it is 1,148.

MAXIMUM POWER OF THE LOCOMOTIVE.

From the diagrams (Figs. 909 and 910) the draw-bar pull that this locomotive is capable of exerting for a considerable

TABLE No. 912—MACHINE EFFICIENCY.

Identification of Test		Duration of Test, Minutes	Machine Friction in			Machine Efficiency, Per Cent.
Test Number	Laboratory Designation		Horse-Power	Mean Effective Pressure, Lbs. Per Sq. Inch	Draw-Bar Pull, Pounds	
		(Cal)	(395)	(396)	(397)	(398)
901	80-15-F	180	92.5	13.34	1816	77.96
902	80-20-F	180	87.4	12.57	1716	81.68
904	80-25-F	180	86.0	12.40	1689	85.35
906	80-30-F	180	95.6	13.78	1880	86.87
	Average		**90.4**	**13.02**	**1777**	
908	120-20-F	180	131.4	12.63	1652	80.89
910	120-25-F	180	130.1	12.50	1702	84.71
912	120-30-F	150	114.6	11.01	1499	88.71
	Average		**125.4**	**12.05**	**1618**	
913	160-15-F	180	180.6	13.01	1417	75.88
914	160-20-F	180	160.9	11.60	1579	80.54
916	160-25-F	150	180.9	13.03	1775	82.11
917	160-27-F	180	162.9	11.74	1599	84.56
918	160-30-F	60	158.4	11.41	1554	86.02
	Average		**168.7**	**12.16**	**1585**	
920	200-20-F	150	229.2	13.21	1805	77.49
922	200-25-F	72	243.1	14.01	1909	80.13
	Average		**236.2**	**13.61**	**1857**	
923	240-15-F	90	204.7	8.43	1148	81.14
924	240-20-F	60	261.7	12.57	1713	77.53
	Average		**233.2**	**10.50**	**1431**	
927	280-15-F	60	331.2	13.64	1858	71.89

length of time has been estimated by the method formerly used in connection with the St. Louis tests, and which will be repeated here as applied to this locomotive.

The maximum power of a locomotive depends upon the relation between the amount of water which can be evaporated by the boiler and the efficiency of the cylinders; for example, if the maximum evaporative power of a locomotive boiler is W pounds of dry steam per hour and the cylinders require N pounds of dry steam per horse-power hour, then the maximum horse-power of the locomotive is represented by $\frac{W}{N}$, except that the maximum power may be limited by the adhesion of the driving wheels at

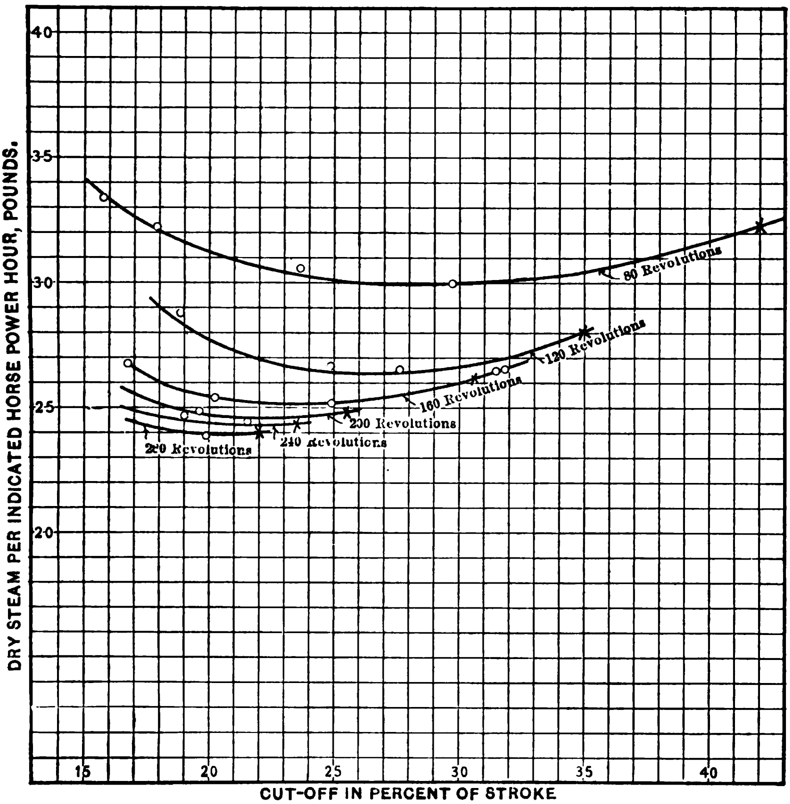


FIG. 909—STEAM CONSUMPTION.

low speeds. The maximum evaporative power of this boiler under the conditions of these tests is about 30,000 pounds of dry steam per hour. Fig. 909 shows the relation between steam consumption per indicated horse-power and cut-off at the several speeds. Similarly, Fig. 910 shows the relation between indicated horse-power and cut-off for the several speeds.

In each diagram the curves have been extended beyond the actual experimental points.

It is now only necessary to select for each speed the cut-off at which the product of indicated horse-power, as shown by Fig. 910 and steam consumption, as shown by Fig. 909, is approximately 30,000 pounds (the maximum capacity of the boiler.) These critical cut-offs are indicated on the diagrams (Figs. 909

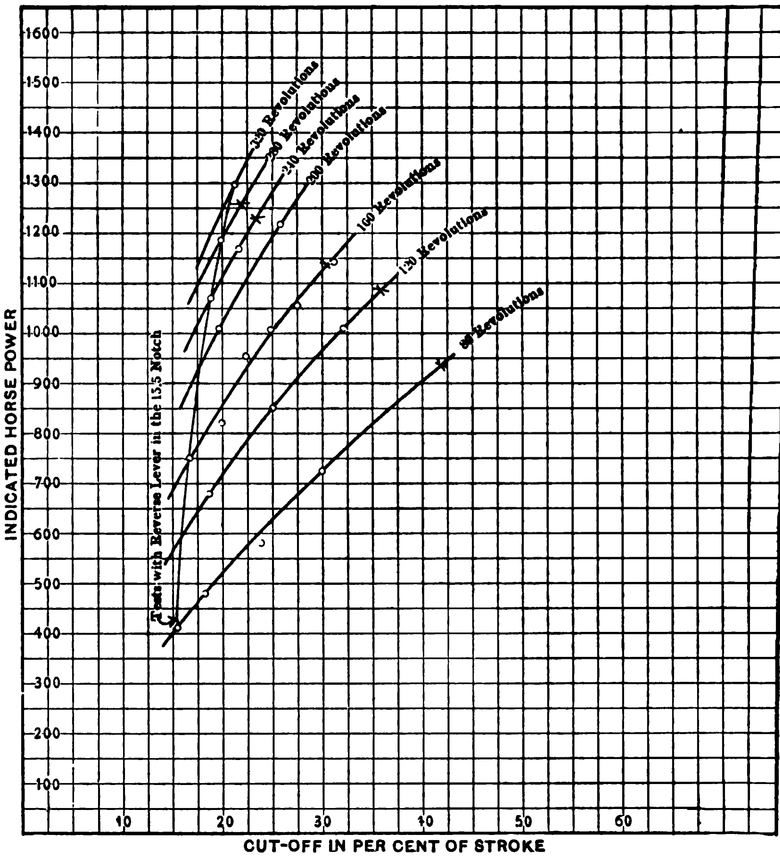


FIG. 910—INDICATED HORSE POWER.

and 910) by a cross mark, and the value of the several factors are shown in the following table:

Nominal Speed R. P. M.	Cut-off in Per Cent.	Steam Per I. H. P. Hour.	Maximum Cylinder Horse-Power.
80	42	32.3	940
120	35	28.0	1075
160	30.5	26.3	1150
200	25.5	24.9	1220
240	23.5	24.4	1240
280	22	24.0	1250

The cylinder horse-power given in the last column of the above table is what would be expected by indicator if tests had been run under the conditions of maximum power at the several

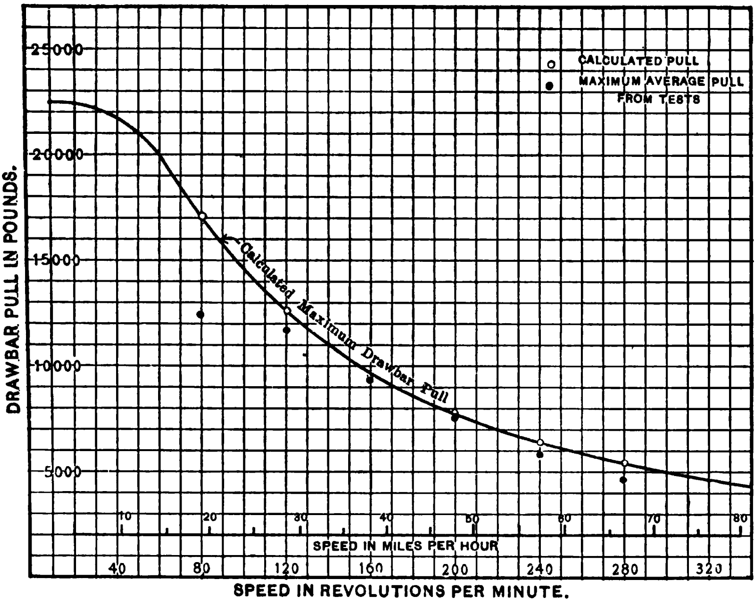


FIG. 911—MAXIMUM DRAW-BAR PULL.

speeds and cut-offs. The cylinder horse-power as found above is now reduced to an equivalent draw-bar pull by the following equation in which S is the speed in miles per hour and F is the corresponding average frictional draw-bar pull (which has been assumed as the average obtained for the whole series of tests, or 1,687 pounds):

$$\text{Maximum Draw-bar Pull} = \frac{\text{Max. Horse-power x } 375}{S} - F$$

The maximum draw-bar pulls at the several speeds, as determined from the above equation, are as follows:

Speed in R. P. M.	Max. Estimated Draw-bar Pull. Pounds.
80	16,768
120	12,384
160	9,602
200	7,894
240	6,428
280	5,325

In Fig. 911 the draw-bar pull is shown graphically with the maximum results obtained in the tests. At speeds of 120, 160, 200, 240 and 280 the maximum pulls developed in the tests approached closely the calculated maximum.

The calculated tractive power at starting is 22,500 pounds, and it is probable that the slowest speed at which the full power of the boiler could be utilized is about 40 revolutions per minute, or about 10 miles per hour.

COMPARISON OF TWO ATLANTIC TYPE PASSENGER LOCOMOTIVES.

Of the passenger locomotives tested at St. Louis in 1904, the New York Central locomotive, No. 3000, resembled Pennsylvania Railroad locomotive No. 5266 in general dimensions, weight and class of service for which it was designed. It was, however, a four-cylinder balanced compound, while the 5266 is a simple locomotive.

In order to show a comparison of the results obtained on a simple and a compound locomotive, the following diagrams have been prepared from the results of tests on these two locomotives. Before taking up the discussion of these diagrams, however, some of the principal dimensions of the locomotives are given in parallel columns in order to show in what particulars they differ.

	N. Y. C. R. R. No. 3000.	P. R. R. No. 5266
Total weight of locomotive working order, lbs.....	200,000	184,167
Weight on drivers, locomotive, working order, lbs.	110,000	110,001
Cylinders, diameter and stroke, inches	15½x26x26	20½x26
Driving wheels, diameter, inches	79	80
Boiler, diameter, inches...	72¼	67
Tubes, number	390	315
" diameter, inches...	2	2
" length, " ...	191.29	179.78
Heating surface, fire-box, (fire side), sq. ft.......	202.83	156.86
Heating surface, tubes (fire side), sq. ft.......	2848.36	2162.4
Heating surface, total (fire side), sq. ft.......	3051.19	2319.26
Grate area, sq. ft........	49.9	55.5
Ratio heating surface to grate surface	61.10	41.79
Boiler volume, cubic feet steam space	77.41	109.9
Boiler volume, cubic feet water space	331.66	338.6

Boiler Performance.

The coal used was that from the Scalp Level mines of the Berwind-White Coal Mining Company, both for the 3000 at St. Louis and the 5266 at Altoona.

In Fig. 1, where the fire-box and smoke-box temperatures are plotted, the differences between the two locomotives are small. The 3000 had a brick arch in the fire-box, but no difference in

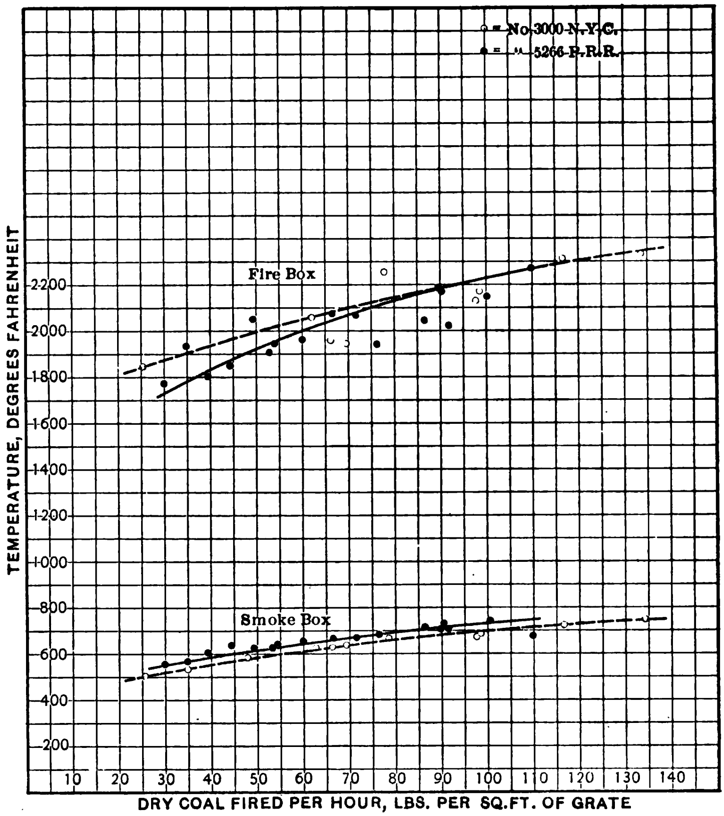


FIG. 1—FIRE BOX AND SMOKE BOX TEMPERATURES.

fire-box temperature is evident as due to this cause. The smoke-box temperature of the 3000, which had a greater length of tube than the 5266, is shown to be lower throughout the tests, indicating that this greater tube length absorbed a larger part of the heat in the gases of combustion than the shorter tubes of he 5266.

In Fig. 2, where the equivalent evaporation per pound of dry coal is given for different rates of evaporation per square foot of heating surface, no difference is found between the two boilers. In other words, the efficiency of a square foot of heating surface in the boiler of 5266 is the same as the efficiency of a square foot of heating surface in the boiler of No. 3000, and this is true for all rates of evaporation.

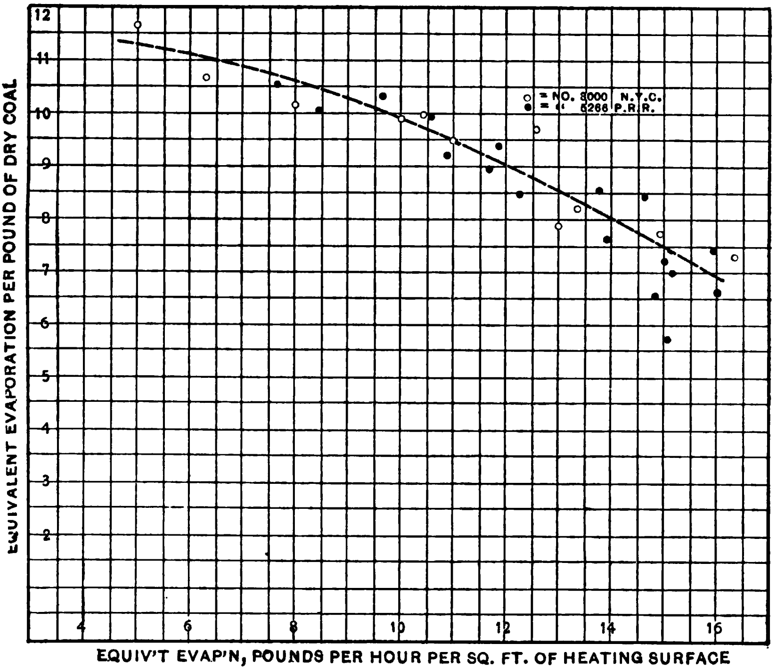


FIG. 2—EVAPORATION.

For two boilers so similar in general type this is to be expected, as there is no reason to suppose that the heating surfaces of the two boilers will have materially different rates of heat transmission to the water when the steel plates are clean as in the case of these two boilers. When, however, the equivalent evaporation per pound of coal is plotted according to the rate of combustion as in Fig. 3, the advantage of the larger heating surface per foot of grate in the 3000 is at once apparent, and this advantage of the 3000 in economical evaporation is maintained throughout the full range of steam delivery of the two boilers.

The highest equivalent evaporation per square foot of heating surface is nearly the same for each boiler, being 16.34 pounds per hour in the case of the 3000 and 16.03 pounds for the 5266.

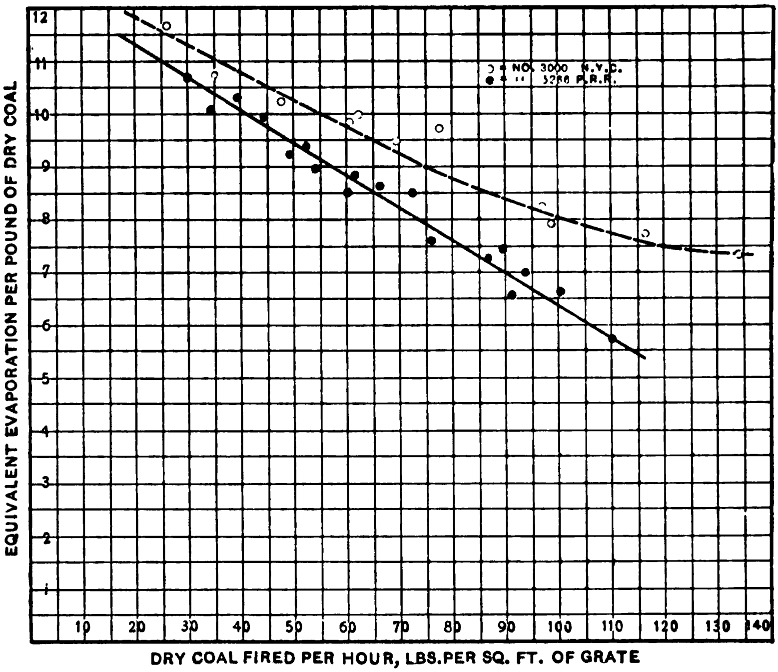


FIG. 3—EVAPORATION.

With the boiler of No. 3000 the greatest loss of heat due to the presence of carbon monoxide in the products of combustion, or, in other words, the greatest loss due to poor combustion was but 1¼ per cent., and in only one other test was it as much as 1 per cent. In the case of the 5266, the losses, while in all cases comparatively small, are in one tesst 9.13 per cent., and in two others 6.06 per cent. and 7.3 per cent. The very perfect combustion shown by the 3000 is, in all probability, due to the brick arch in the fire-box of this locomotive. There was no arch in the 5266.

The 3000 was fitted with smoke-box deflectors or diaphragms which made the smoke-box completely self-cleaning, while the 5266 did not have a self-cleaning front, and this was one of the limiting factors in maximum evaporation obtained with long cut-offs, due to the accumulation of cinders in the front end, which

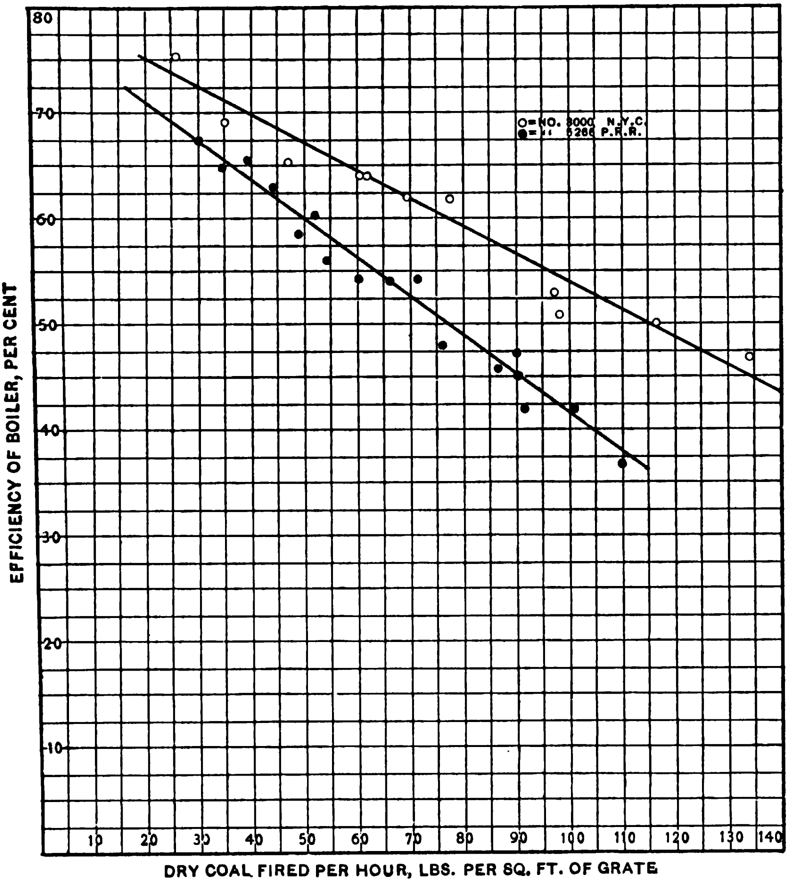


FIG. 4—BOILER EFFICIENCY.

interfered with the draft, and, consequently, the steaming capacity. The results from the action of the two smoke-boxes are shown in Figure 5½.

Engine Performance.

In Fig. 5 the well-established fact that the engines of a compound locomotive within limits, operate on less steam per unit of power than the engines of a simple locomotive, is shown.

The diagram shows very clearly another fact that is not so generally recognized, and that is that the difference in the water rate or steam per horse-power hour is not a constant difference expressable as a certain definite percentage of saving. When

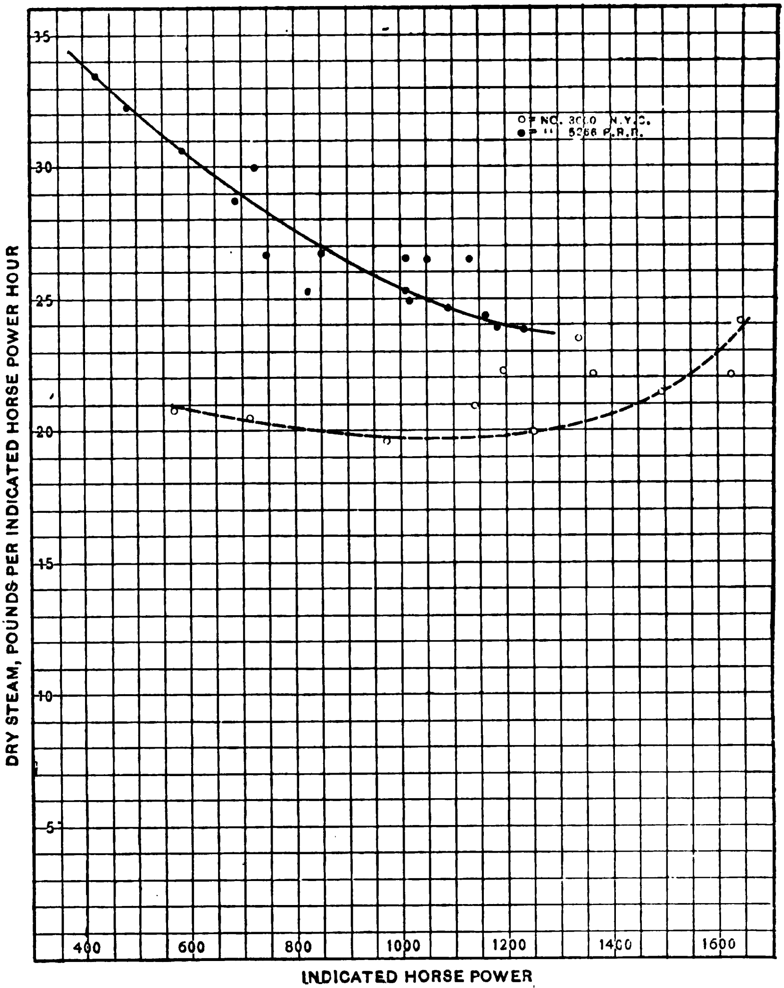


FIG. 5—STEAM PER INDICATED HORSE POWER.

each of the locomotives is developing 600 horse-power, there is a difference in the steam per horse-power of about 9.7 pounds, or a saving of 31.8 per cent., while at 1300 horse-power the saving is but 3.5 pounds, or 14.9 per cent.

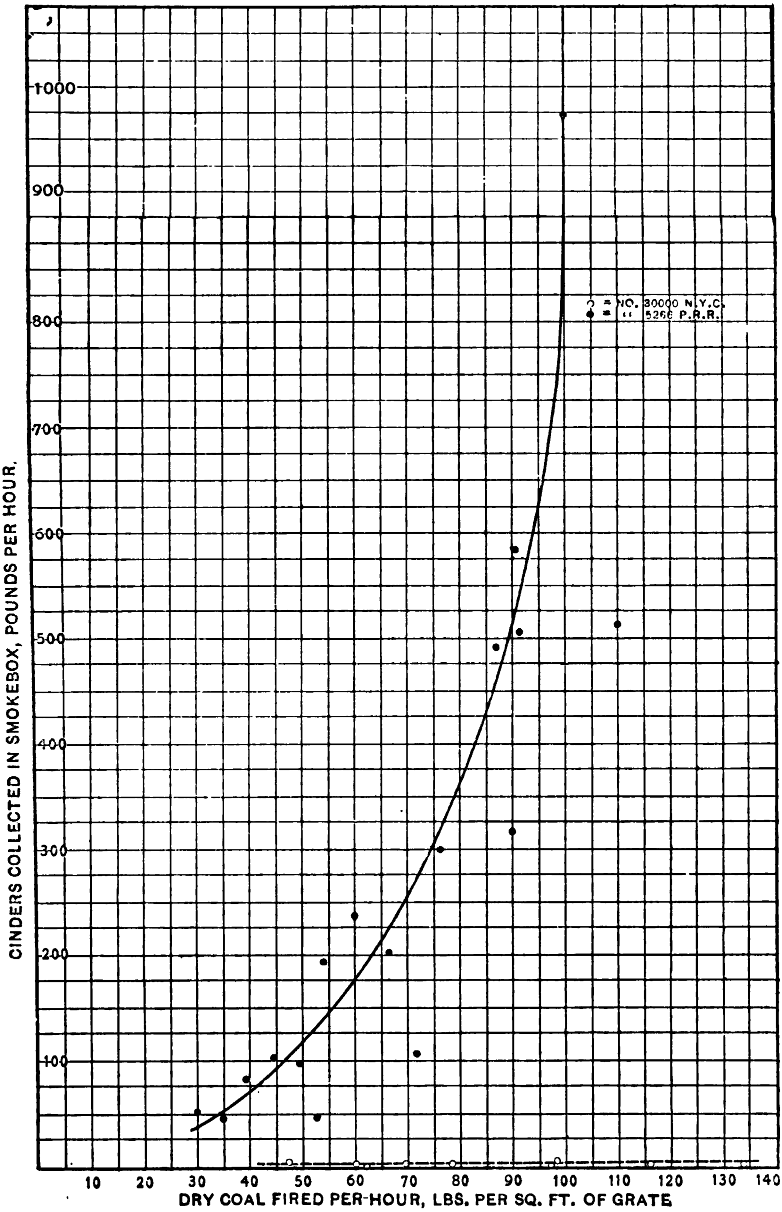


FIG. 5½—CINDERS IN SMOKE BOX.

The two curves show that the water rates of the two locomotives would, perhaps, meet at about 1600 horse-power were it possible to drive the 5266 to such a point, and as the high horse-powers were obtained, as a rule, at the higher speeds, the curves would indicate that the simple locomotive is working most economically at its highest speeds, while the reverse is true of the compound.

It will be remembered that in the case of the simple and compound freight locomotives tested at St. Louis the conclusions arrived at in regard to the steam consumption were as follows: "In general the steam consumption of the simple engines decreased with increase in speed, while that of the compounds increased, which would lead to the conclusion that the steam distribution of the compounds was less satisfactory at high speeds than that of the simple."* The maximum horse-power developed by the 3000 was 1641, while the maximum for the 5266 was 1281.

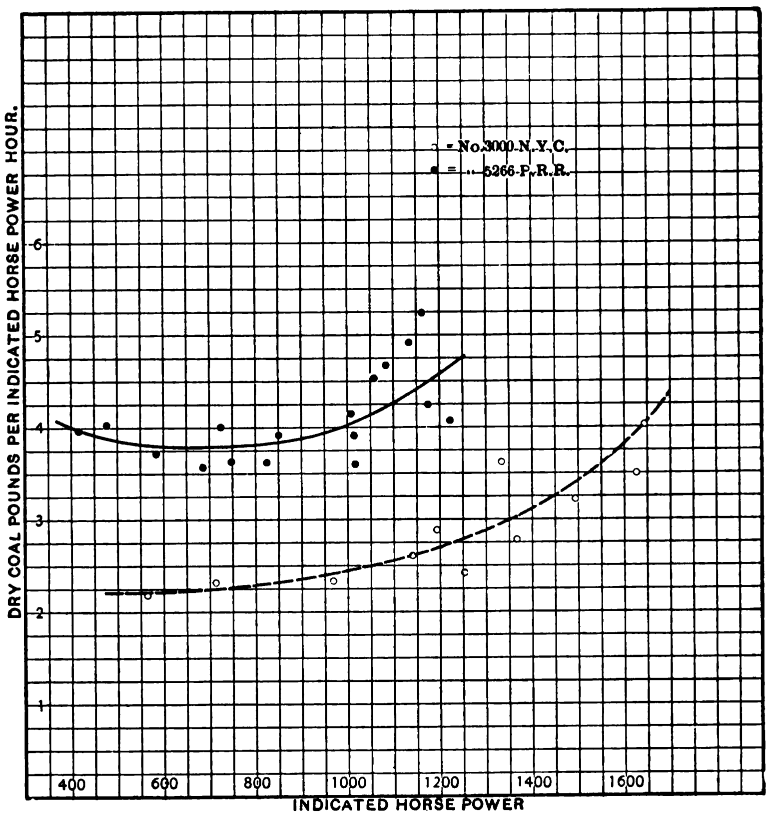


FIG. 6—COAL PER INDICATED HORSE POWER.

* See "Locomotive Tests and Exhibits," page 706.

In Fig. 2 we have seen that the evaporation per pound of coal decreases as the output of the boiler in steam increases, and this decrease explains the difference in the appearance of the curves in Figs. 5 and 6. It would appear at first sight as though the curves for coal per indicated horse-power hour should follow the same law as do the curves for steam, and this would be the case if it were not for the fact that as the output of the boiler increases, it is at the expense of a greater and greater quantity of coal per pound of water evaporated.

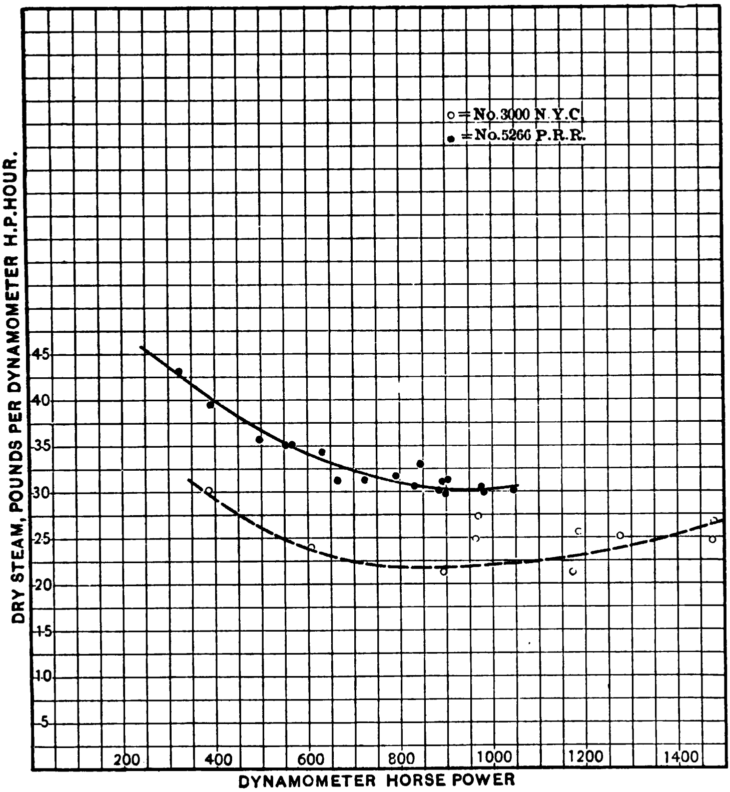


FIG. 7—STEAM PER DYNAMOMETER HORSE POWER.

LOCOMOTIVE PERFORMANCE.

In Fig. 10 is shown the dry steam used by the locomotives at different indicated horse-powers. The 3000, compound, requires at all powers less steam than the 5266, simple locomotive, but as the limit of power is approached by the compound the steam rate advances more rapidly than would apparently be the case with a simple locomotive. This is only another way of showing that the advantage of compounding may not be realized at high speeds, as was developed in the discussion of Fig. 5, as judged by the two locomotives under discussion.

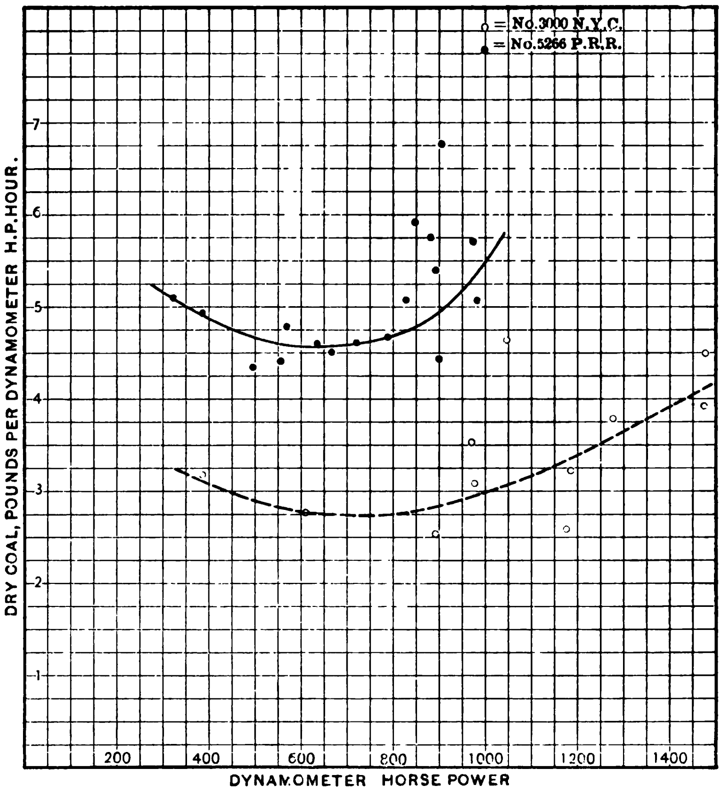


FIG. 8—COAL PER DYNAMOMETER HORSE POWER.

One of the most significant results of this comparison of a simple with a compound locomotive is the large increase in horse-power and draw-bar pull that can be realized from compounding without any increase in the boiler capacity. This is a very important advantage aside from all considerations of economy in the use of fuel.

Let us assume that the boiler of each locomotive will deliver 30,000 pounds of dry steam per hour to the engines. With this weight of steam the simple locomotive, No. 5266, will develop

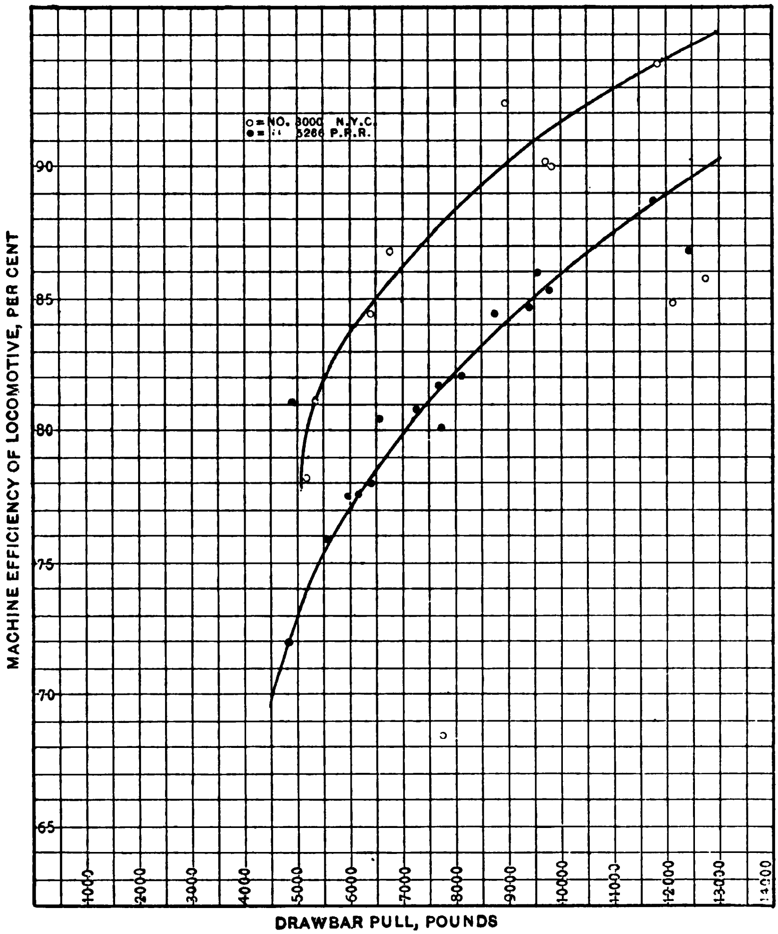


FIG. 9—MACHINE EFFICIENCY.

1200 indicated horse-power, while the compound, No. 3000, will develop 1400 indicated horse-power. To show what this will mean in increased draw-bar pull, due to compounding at several speeds, the following table has been arranged:

Comparative Performance.

At 40 miles per hour, using 30,000 pounds of water per hour:

Locomotive	Type	Machine Efficiency	Indicated Horse Power	Dynamometer Horse Power	Draw-Bar Pull	Increase in Draw-Bar Pull from Compounding
5266	4—4—2 Simple	86	1200	1032	9674	
3000	4—4—2 Compound	86	1400	1204	11287	+1613

At 50 miles per hour, using 30,000 pounds of water per hour:

5266	Simple	79	1200	948	7110	
3000	Compound	79	1400	1106	8294	+1184

At 60 miles per hour, using 30,000 pounds of water per hour:

5266	Simple	77	1200	924	5775	
3000	Compound	77	1400	1078	6737	+ 962

The above table shows what might be expected in increased power if the cylinders of locomotive No. 3000 were to be applied to locomotive No. 5266.

The probable result in fuel saving with this combination of the compound cylinders and the boiler of No. 5266, working as before at about its maximum rate of evaporation, that is, delivering 30,000 pounds of dry steam per hour, will be as shown in the following table.

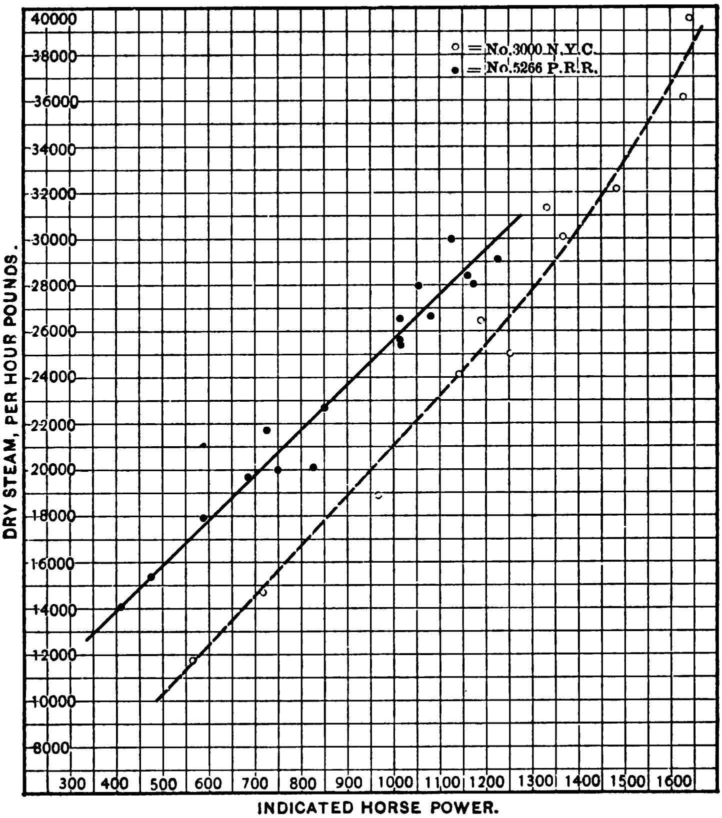


FIG. 10—STEAM AND HORSE POWER.

Coal Per Dynamometer Horse-Power Hour for Locomotive 5266, With Its Present Simple Cylinders and the Results to be Expected If the Present Boiler Were to be Fitted With Compound Cylinders Similar to Those on No. 3000:

Assumed Evaporation Lbs. of Dry Steam Per Hour	Corresponding Dry Coal Burned Per Hour, Pounds	Dynamometer Horse Power Locomotive With		Speed, Miles Per Hour	Dry Coal Per Dynamometer H. P. Hour.		Difference in Favor of Compound Cylinders, Pounds of Coal	Saving Expressed as a Percentage
		Simple Cylinders	Compound Cylinders		Locomotive With Simple Cylinders	Same Boiler With Compound Cylinders		
30,000	4983	1032	1204	40	4.82	4.13	.69	14.3
30,000	4983	948	1106	50	5.25	4.51	.74	14.1
30,000	4983	924	1078	60	5.39	4.62	.77	14.3

It will be noted that this percentage of saving agrees closely with that observed under engine performance. It is also the saving at a point where the simple locomotive is at its best, as before noted, namely, at its maximum horse-power. Other lower rates of evaporation might be selected where percentages of saving would be much higher.

APPENDIX

The appendix contains:

1. Description, dimensions and proportions of the locomotive. (pp. 48 to 53 inclusive.

2. Summary of average results of tests. (pp. 54 to 64 inclusive.

3. Graphical running logs showing boiler pressure, total water, total coal, revolutions per minute, and draw-bar pull for each test. Each diagram was plotted during the test to which it refers. (pp. 65 to 73 inclusive.)

4. Plots showing relations between important items of the tests. (pp. 74 to 103 inclusive.)

5. Vibration Diagrams. (pp. 104 to 106 inclusive.)

6. Typical indicator diagrams. A representative set of diagrams from each test is shown. (pp. 107 to 111 inclusive.)

7. A typical dynamometer diagram for each nominal speed. (pp. 112 to 115.)

8. Illustrations of the locomotive showing important details and location of testing instruments.

Description, Dimensions and Proportions of Pennsylvania E2a Atlantic (4-4-2) Type Locomotive No. 5266.

Built at the Juniata Shops of the Pennsylvania Railroad, Altoona, Pa., July, 1904.

Driving Wheels.

1	Number of pairs	2
2	Approximate diameter, inches	80

MEASURED CIRCUMFERENCE, FEET.

			After March 1, 1907.
3	Right, No. 1	20.91	21.01
4	" " 2	20.91	21.01
5	" " 3		——
6	" " 4		——
7	" " 5		——
8	Left, " 1	20.91	21.01
9	" " 2	20.91	21.01
10	" " 3		——
11	" " 4		——
12	" " 5		——
13	Average	20.91	21.01

ENGINE TRUCK WHEELS.

14	Number	4
15	Diameter, inches	36

TRAILING WHEELS.

16	Diameter, inches	50

WHEEL BASE, FEET.

17	Driving wheel base	7.42
18	Total wheel base	30.85
19	Gauge of wheels, in inches	56.13

WEIGHT OF ENGINE WITH WATER AT SECOND GAUGE COCK AND NORMAL FIRE, IN POUNDS.

20	On truck	37,167
21	" 1st drivers	53,334
22	" 2nd "	56,667
23	" 3rd "	——
24	" 4th "	——
25	" 5th "	——
26	" trailers	37,000
27	Total	184,167
28	" on drivers	110,001

CYLINDERS.

29	High pressure, number	2
30	Low " "	——
31	Arrangement	Outside

DIAMETER, INCHES.

32	High pressure, right	20.518
33	“ “ left	20.812
34	Low “ right	——
35	“ “ left	——

STROKE OF PISTON, FEET.

36	High pressure, right	2.164
37	“ “ left	2.164
38	Low “ right	——
39	“ “ left	——

CLEARANCE PER CENT. OF PISTON DISPLACEMENT.

40	H. P., right, head end	12.7
41	“ “ crank “	12.1
42	“ left, head “	12.4
43	“ “ crank “	11.9
44	L. P., right, head end	——
45	“ “ crank “	——
46	“ left, head “	——
47	“ “ crank “	——

RECEIVER, CUBIC FEET.

48	Volume, right side	——
49	“ left “	——

STEAM PORTS, INCHES.

(*For piston valves the length equals the circumference of inside of bushing minus the sum of the widths of bridges.*)

50	H. P. admission, right, head end, length	19.87
51	“ “ “ “ “ width	1.48
52	“ “ “ crank “ length	19.82
53	“ “ “ “ “ width	1.48
54	“ “ left, head “ length	19.83
55	“ “ “ “ “ width	1.48
56	“ “ “ crank “ length	19.86
57	“ “ “ “ “ width	1.48
58	L. P. “ right, head “ length	——
59	“ “ “ “ “ width	——
60	“ “ “ crank “ length	——
61	“ “ “ “ “ width	——
62	“ “ left, head “ length	——
63	“ “ “ “ “ width	——
64	“ “ “ crank “ length	——
65	“ “ “ “ “ width	——
66	H. P. exhaust, right, length	19.84
67	“ “ “ width	2.98
68	“ “ left, length	19.92
69	“ “ “ width	2.98

70 L. P. " right, length .... ——
71 " " " width .... ——
72 " " left, length .... ——
73 " " " width .... ——

PISTON RODS, DIAMETER, INCHES.

74 High pressure, right.......................... 3.472
75 " " left 3.501
76 Low " right .... ——
77 " " left .... ——

TAIL RODS, DIAMETER, INCHES.

78 High pressure, right.......................... ——
79 " " left .... ——
80 Low " right .... ——
81 " " left .... ——

VALVES.

82 Type.............Wilson Balanced Double Ported Slide
83 Design....................American Balance Valve Co.
84 Per cent. of balanced to total area.............. 75.70
85 Type of link motion........................Stephenson

GREATEST VALVE TRAVEL, INCHES.

86 High pressure, right.......................... 7.0
87 " " left 7.2
88 Low " right .... ——
89 " " left .... ——

OUTSIDE LAP OF VALVE, INCHES.

90 High pressure, right, head end.................. 1.5
91 " " " crank " 1.5
92 " " left head " 1.5
93 " " " crank " 1.5
94 Low " right, head " .... ——
95 " " " crank " .... ——
96 " " left, head " .... ——
97 " " " crank " .... ——

INSIDE LAP OF VALVE, INCHES.

98 High pressure, right, head end...........negative .16
99 " " " crank " .... .16
100 " " left, head " .... .14
101 " " " crank " .... .14
102 Low " right, head " .... ——
103 " " " crank " .... ——
104 " " left, head " .... ——
105 " " " crank " .... ——

MISCELLANEOUS.

106 Cylinder lagging material...................Magnesia
107 " jacket " ....Sheet iron
108 Lead, forward motion, right................ $\frac{11}{64}$ negative
109 " " " left................. $\frac{4}{64}$ "

110	Area of steam port in valve, sq. in.	8.20
111	" " exhaust " " " " "	8.20
112	....	
	BOILER.	
113	Type	Belpaire, wide fire-box
114	Outside diameter, first ring, inches	67.0
	TUBES.	
115	Number	315
116	Outside diameter, inches	2.00
117	Thickness, inches	.125
118	Length between tube sheets, inches	179.78
119	Total fire area, square feet	5.26
120	Serve Tubes, number of ribs	——
121	" " sq. in. of inside surface in one in. of length	——
122	....	
123	....	
124	Boiler pressure, lbs. per sq. in.	205
	SUPERHEATER.	
125	Number of tubes	——
126	Outside diameter, inches	——
127	Thickness, inches	——
128	Length of tubes, inches	——
129	....	
130	....	
131	....	
	FIRE-BOX (SIZE INSIDE, INCHES).	
132	Length	114.0
133	Width	68.0
134	Depth, front end	61.0
135	" back "	55.25
136	Volume, cubic feet (no arch)	233.31
137	Air inlets to ashpan (dampers closed), sq. ft.	0.0
138	" " " " (" open), " "	2.3
139	" " " " increased, 11-27-'06, to	6.3
140	....	
	FIRE DOORS.	
141	Number	1
142	Area, square feet	1.59
143	....	
	GRATES.	
144	Style	Rocking finger
145	Total area, square feet	55.5
146	" " dead grates, square feet	6.0
147	Width of air spaces, inches	.75
	AIR INLET AREAS, SQUARE FEET.	
148	Through fire-box sides	.00
149	" grates	15.00
150	" fire doors	.03

151 Total air inlets, (148), (149) and (150).......... 15.03
152 Ratio " " (149) to grate area (145)........ 0.27
153 " " " (151) " " " (145) 0.27

HEATING SURFACE, SQUARE FEET.

154 Of the tubes, water side...................... 2471.04
155 " " " fire " 2162.40
156 " " fire-box, fire side.................... 156.86
157 " " superheater, fire side.................. ———
158 Total, based on inside of fire-box and inside of tubes 2319.26
159 Total, based on inside of fire-box and outside of tubes 2627.90

BOILER VOLUMES.

With water surface at level of second gauge cock.

160 Water space, cubic feet......................... 338.6
161 Steam " " " 109.9

EXHAUST NOZZLE.

162 Double or single..............................Single
163 Size of right, inches } Diam..................... 5.625
164 " " left, " } ....
165 Area of right, square inches } 24.85
166 " " left, " " } ....
167 Total area, square inches........................24.85

REVERSE LEVER.

168 H. P. cylinder, notches forward of centre.......... 15
169 L. P. " " " " " ....
170 ....

RATIOS.

171 Heating surface (158) to grate area (145)........ 41.79
172 Fire area through tubes (119) to grate area (145) .09
173 Fire-box heating surface (156) to grate area (145) 2.83
174 Tube surface (155) to fire-box heating surface (156) 13.79
175 Fire-box volume (136) to grate area (145)...... 4.20
176 ....
177 ....
178 ....

CONSTANTS FOR DYNAMOMETER HORSE POWER.

(*Power developed at one R. P. M. when pull is one pound.*)

179 ....0006367 and .0006336

CONSTANTS FOR INDICATED HORSE POWER.

(*Power developed at one R. P. M. and one pound M. E. P.*)

180 High pressure, cylinder, right, head end........ .02168
181 " " " " crank " .... .02106
182 " " " left head " .... .02231
183 " " " " crank " .... .02168
184 Low " " right, head " .... ———
185 " " " " crank " .... ———
186 " " " left, head " .... ———
187 " " " " crank " .... ———

PISTON DISPLACEMENT, CUBIC FEET.

188	High	pressure	cylinder,	right	head	end..........	4.97
189	"	"	"	"	crank	"	4.83
190	"	"	"	left,	head	"	5.11
191	"	"	"	"	crank	"	4.97
192	Low	"	"	right,	head	"	——
193	"	"	"	"	crank	"	——
194	"	"	"	left,	head	"	——
195	"	"	"	"	crank	"	——

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.
PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Hours Duration of Test	Speed: Revolutions: Total	Speed: Revolutions: Average Per Minute	Speed: Equivalent: Speed in Miles Per Hour	Speed: Equivalent: Piston Speed in Feet Per Minute	Position of Levers: Reverse Notches from Front End	Position of Levers	Position of Levers: Throttle	Coal Loss Due to Steam Loss, Pounds Per Hour	
		196	197	198	199	200	201	202	203	204	205
901	80-15-F	3.00	14400	80.00	19.10	346.2	15.5		Full	51.15	
902	80-20-F	3.00	14400	80.00	19.10	346.2	15.0		"	64.40	
904	80-25-F	3.00	14398	79.99	19.09	346.2	14.0		"	46.08	
906	80-30-F	3.00	14401	80.00	19.01	346.2	13.0		"	66.58	
908	120-20-F	3.00	21600	120.00	28.65	519.2	15.0		"	47.78	
910	120-25-F	3.00	21600	120.00	28.65	519.2	14.0		"	56.80	
912	120-30-F	2.50	18000	120.00	28.65	519.2	14.0		"	111.90	
913	160-15-F	3.00	28800	160.00	38.20	632.4	15.5		"	70.52	
914	160-20-F	3.00	28800	160.00	38.20	692.4	15.0		"	120.00	
916	160-25-F	2.50	24000	160.00	38.20	692.4	14.0		"	104.00	
917	160-27-F	3.00	28800	160.00	38.20	692.4	13.5		"	72.42	
918	160-30-F	1.00	9600	160.00	38.20	692.4	13.0		"	66.06	
920	200-20-F	2.50	30000	200.00	47.75	865.6	15.0		"	79.43	
922	200-25-F	1.20	14400	200.00	47.75	865.6	14.0		"	138.20	
923	240-15-F	1.50	21600	240.00	57.30	1038.8	15.5		"	71.48	
924	240-20-F	1.00	14400	240.00	57.30	1038.8	15.0		"	2.37	
927	280-15-F	1.00	16800	280.00	66.85	1211.8	15.5		"	94.91	
929	320-15-F	—	—	—	76.08	—	15.5		"	—	

Test Number	Laboratory Designation	Temperature, Degrees Fahrenheit, of: Smoke Box: By Thermometer	Smoke Box: By Pyrometer	Laboratory: Wet Bulb	Laboratory: Dry Bulb	Steam in Branch Pipe	Feed Water	Fire Box By Pyrometer				Steam Lost from Boiler, Lbs. Per Hr.
		206	207	208	209	210	211	212	213	214	215	216
901	80-15-F		502	61.0	54.0	386.8	48.0	1774				446
902	80-20-F		579	64.0	54.5	386.5	46.4	1918				530
904	80-25-F		618	65.0	58.3	388.8	48.0	1803				388
906	80-30-F		630	59.0	48.0	387.5	40.0	1915				506
908	120-20-F		644	69.3	62.8	390.8	48.5	1859				388
910	120-25-F		672	61.8	52.3	398.6	47.6	1965				388
912	120-30-F		665	64.0	57.0	399.1	42.2	2077				770
913	160-15-F		633	60.0	53.5	395.2	45.2	2078				537
914	160-20-F		654	55.5	45.5	398.6	43.7	1952				874
916	160-25-F		681	46.5	42.0	404.2	42.2	1935				645
917	160-27-F		719	60.0	53.5	417.2	46.8	2058				428
918	160-30-F		740	61.5	50.0	418.4	50.1	2143				360
920	200-20-F		679	53.0	49.0	403.6	42.6	2076				556
922	200-25-F		694	54.0	48.0	408.7	41.8	2180				832
923	240-15-F		693	60.5	52.0	400.9	40.8	2025				381
924	240-20-F		675	61.0	51.0	401.8	40.5	2266				11
927	280-15-F		715	51.5	45.0	398.8	41.0	2165				541
929	320-15-F		—	—	—	—	—	—				—

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.
PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Pressure, Lbs. Per Sq. In. — In Boiler — Average	Maximum	Minimum	In Branch Pipe	Air in Laboratory Barometric	Draft, Inches of Water — In Smoke Box — Front of Diaphragm	Back of Diaphragm	In Fire Box	In Ash Pan	Injectors — Hrs. in Action — Total, Right	Total, Left
		217	218	219	220	221	222	223	224	225	226	227
901	80-15-F	201.3	205.0	196.0	198.3	14.06	2.0	1.8	0.6	0.2	2.9	0
902	80-20-F	200.1	206.0	196.0	197.3	14.16	2.1	1.9	0.8	0.1	2.9	0
904	80-25-F	198.5	201.5	196.0	192.8	14.19	3.3	3.1	1.4	0.7	3.0	0
906	80-30-F	202.6	211.0	195.0	199.8	14.15	3.4	2.9	0.7	0.3	3.0	0
908	120-20-F	201.0	203.0	197.0	197.7	14.06	3.9	3.4	1.7	0.7	3.0	0
910	120-25-F	200.5	203.5	197.0	197.5	14.12	5.1	4.5	2.3	1.0	3.0	0
912	120-30-F	202.7	206.5	191.0	197.8	14.10	4.9	4.2	1.4	0.3	2.49	0
913	160-15-F	198.0	204.0	173.0	195.0	14.24	3.1	2.8	0.9	0.2	2.81	0
914	160-20-F	202.9	206.0	200.0	198.2	14.30	3.7	3.2	1.2	0.2	3.00	0
916	160-25-F	200.0	205.0	197.0	195.0	14.37	5.2	4.4	1.5	0.3	2.50	0
917	160-27-F	188.4	204.5	171.0	185.6	14.15	7.7	6.2	2.1	0.3	3.0	0
918	160-30-F	186.1	195.5	176.0	181.8	14.11	8.9	8.0	3.0	1.3	1.0	0
920	200-20-F	202.0	205.0	199.0	197.4	14.12	5.0	4.2	1.3	0.2	2.5	0
922	200-25-F	202.1	205.5	197.0	197.1	14.30	6.0	5.1	1.6	0.3	1.2	0
923	240-15-F	196.4	205.0	181.0	194.2	13.97	5.6	4.7	1.3	0.2	1.5	0
924	240-20-F	197.5	203.0	191.0	195.1	14.04	5.4	4.6	1.4	0.3	1.0	0
927	280-15-F	194.4	207.0	182.0	191.7	14.03	5.6	4.9	1.5	0.2	1.0	0
929	320-15-F	—	—	—	—	—	—	—	—	—	—	—

Test Number	Laboratory Designation	Quality of Steam — In Dome	In Branch Pipe	Degrees of Superheat in Branch Pipe	Factor of Correction Dome	Coal, Sparks and Ash, Pounds — Coal Fired — Kind	Total	Per Cent of Moisture	Total — Dry Coal Fired	Combustible By Analysis	Ash by Analysis
		228	229	230	231	232	233	234	235	236	237
901	80-15-F	.9856	.9983	0	.9898	Bituminous	5134	2.72	4994	4723	271
902	80-20-F	.9866	.9997	—	.9905	"	5872	1.20	5802	5392	409
904	80-25-F	.9860	1.0022	4.00	.9901	"	6598	1.04	6530	6140	397
906	80-30-F	.9845	.9994	0	.9891	"	8896	1.11	8797	8212	585
908	120-20-F	.9860	1.0024	4.2	.9901	"	7442	1.04	7365	6926	448
910	120-25-F	.9860	1.0069	12.08	.9901	"	10112	1.04	10000	9410	608
912	120-30-F	.9851	1.0071	12.43	.9895	"	10107	1.35	9970	9335	634
913	160-15-F	.9864	1.0055	9.6	.9904	"	8415	2.72	8186	7742	444
914	160-20-F	.9854	1.0067	11.72	.9897	"	9247	2.72	8995	8508	487
916	120-25-F	.9859	1.0106	18.57	.9901	"	10848	2.72	10552	9981	572
917	160-27-F	.9860	1.0202	35.51	.9901	"	14557	1.04	14405	13547	876
918	160-30-F	.9860	1.0218	38.38	.9901	"	5640	1.04	5581	5249	339
920	200-20-F	.9856	1.0098	17.16	.9899	"	9494	2.72	9235	8735	500
922	200-25-F	.9859	1.0127	22.23	.9901	"	6062	1.35	5980	5599	381
923	240-14-F	.9850	1.0091	15.93	.9894	"	7706	1.11	7620	7113	507
924	240-20-F	.9860	1.0093	16.29	.9901	"	6169	1.11	6101	5695	406
927	280-15-F	.9854	1.0084	14.73	.9897	"	5068	1.11	5012	4678	333
929	320-15-F	—	—	—	—	"	—	—	—	—	—

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266, PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Coal, Sparks and Ash, Lbs. Per Hour: Cinders Collected in Smoke Box	Sparks Discharged From Stack	Cinders and Sparks	Analysis of Coal, Per Cent.: Fixed Carbon	Volatile Matter	Moisture	Ash	Sulphur, Determined Separately		
		238	239	240	241	242	243	244	245	246	247
901	80-15-F	52	16	68	75.87	16.14	2.72	5.27	0.91		
902	80-20-F	46	10	56	76.06	15.77	1.20	6.97	1.57		
904	80-25-F	82	16	98	76.98	15.96	1.04	6.02	0.91		
906	80-30-F	66	47	113	75.77	16.54	1.11	6.58	1.00		
908	120-20-F	101	23	124	76.98	15.96	1.04	6.02	0.91		
910	120-25-F	236	15	251	76.98	15.96	1.04	6.02	0.91		
912	120-30-F	110	153	263	76.45	15.92	1.35	6.28	0.67		
913	160-15-F	98	43	141	75.87	16.14	2.72	5.27	0.91		
914	160-20-F	194	47	241	75.87	16.14	2.72	5.27	0.91		
916	160-25-F	302	128	430	75.87	16.14	2.72	5.27	0.91		
917	160-27-F	492	140	632	76.98	15.96	1.04	6.02	0.91		
918	160-30-F	987	238	1225	76.98	15.96	1.04	6.02	0.91		
920	200-20-F	204	85	289	75.87	16.14	2.72	5.27	0.91		
922	200-25-F	316	208	524	76.45	15.92	1.35	6.28	0.67		
923	240-15-F	508	84	592	75.77	16.54	1.11	6.58	1.00		
924	240-20-F	514	95	609	75.77	16.54	1.11	6.58	1.00		
927	280-15-F	584	58	642	75.77	16.54	1.11	6.58	1.00		
929	320-15-F	—	—	—	—	—	—	—	—	—	—

Test Number	Laboratory Designation	Calorific Value Per Lb. of Fuel, B. T. U.: Of Dry Coal	Of Combustible	Of Cinders	Of Sparks		Analysis of Smoke-Box Gases, Per Cent.: Oxygen O	Carbon Monoxide CO	Carbon Dioxide CO_2	Nitrogen N		
		248	249	250	251	252	253	254	255	256	257	258
901	80-15-F	15264	16138	11713	10868		9.26	0	10.46	80.26		
902	80-20-F	15077	16221	10370	11784		8.40	0	10.67	80.93		
904	80-25-F	15167	16128	12491	11784		11.80	0	7.80	80.30		
906	80 30-F	15020	16090	11291	10065		8.53	0	9.67	81.80		
908	120-20-F	15167	16128	10606	8484		8.70	0	10.50	80.80		
910	120-25-F	15167	16128	11194	11017		5.40	0	13.60	80.90		
912	120-30-F	15057	16079	11998	12057		6.86	0	11.33	81.80		
913	160-15-F	15264	16138	12770	8910		6.86	0.13	12.20	80.80		
914	160-20-F	15264	16138	11048	9860		10.30	0	9.06	80.60		
916	160-25-F	15264	16138	9287	9042		9.73	.06	9.60	80.60		
917	160-27-F	15167	16128	9701	11617		2.60	.06	14.40	82.40		
918	160-30-F	15167	16128	11497	10899		4.70	.06	12.70	82.00		
920	200-20-F	15264	16138	9471	11378		9.13	.06	10.33	80.46		
922	200-25-F	15057	16079	11523	11198		6.60	1.20	10.20	82.00		
923	240-15-F	15020	16090	10506	9799		5.20	1.60	11.00	82.20		
924	240-20-F	15020	16090	12157	11977		6.40	0.20	11.00	82.40		
927	280-15-F	15020	16090	11472	12197		5.60	2.00	10.60	81.80		
929	320-15-F	—	—	—	—		—	—	—	—		

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.
PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Water, in Pounds: Delivered to Injectors	Lost: From Boiler	Lost: From Injectors	Lost: From	Lost: Total	Delivered to Boiler and Presumably Evaporated	Dynamometer, Draw-Bar Pull in Pounds: Average	Maximum	Minimum
		259	260	261	262	263	264	265	266	267
901	80-15-F	44020	0	0		0	44020	6427	6621	6111
902	80-20-F	48226	0	0		0	48226	7653	7952	7395
904	80-25-F	56041	0	505		505	55536	9810	10441	9603
906	80-30-F	67608	0	0		0	67608	12475	13147	12036
908	120-20-F	60685	0	279		279	60406	7280	7858	6716
910	120-25-F	70109	0	108		108	70001	9438	9638	9213
912	120-30-F	69278	0	0		0	69278	11785	12320	10976
913	160-15-F	62596	0	0		0	62596	5578	5782	5169
914	160-20-F	66120	0	0		0	66120	6538	7300	6146
916	160-25-F	66090	0	0		0	66090	8155	8510	7992
917	160-27-F	86070	0	60		60	86010	8757	9493	7525
918	160-30-F	30721	0	0		0	30721	9571	10149	9008
920	200-20-F	65283	0	0		0	65283	6199	6462	5960
922	200-25-F	36360	0	0		0	36360	7701	8022	7390
923	240-15-F	41048	0	0		0	41048	4940	5204	4460
924	240-20-F	28670	0	0		0	28670	5908	6141	5436
927	280-15-F	28890	0	0		0	28890	4752	5061	4360
929	320-15-F	—	—	—	—	—	—	4424	—	—

Test Number	Laboratory Designation	Events of Stroke from Indicator Cards — Cut-off, Per Cent. of Stroke — High Pressure Cylinder — Right Side: Head End	Crank End	Left Side: Head End	Crank End	Low Pressure Cylinder — Right Side: Head End	Crank End	Left Side: Head End	Crank End	Release, Per Cent. of Stroke — High Pressure Cylinder — Right Side: Head End	Crank End	Left Side: Head End	Crank End
		268	269	270	271	272	273	274	275	276	277	278	279
901	80-15-F	15.4	17.4	15.5	14.7					54.9	52.5	56.1	50.3
902	80-20-F	17.2	20.3	17.2	16.7					58.1	56.0	59.3	53.2
904	80-25-F	24.3	24.6	23.4	22.6					62.8	61.4	65.9	60.1
906	80-30-F	29.8	29.5	30.5	28.9					70.4	65.3	74.5	64.7
908	120-20-F	19.1	20.4	18.4	17.4					60.5	56.5	60.0	53.7
910	120-25-F	26.4	26.0	24.1	23.0					65.3	61.8	65.5	58.7
912	120-30-F	31.2	34.3	31.0	30.2					68.7	65.5	69.4	64.1
913	160-15-F	15.9	18.9	16.8	15.2					54.4	52.3	55.1	48.8
914	160-20-F	18.9	21.3	20.9	19.7					58.5	56.2	63.0	53.9
916	160-25-F	23.0	26.9	24.9	24.6					61.3	59.9	64.5	58.6
917	160-27-F	29.9	27.9	26.8	26.0					67.7	64.7	68.5	63.1
916	160-30-F	33.4	33.6	29.7	29.4					70.1	67.9	69.2	65.0
920	200-20-F	19.3	19.0	20.2	19.3					59.7	57.3	57.5	55.4
922	200-25-F	24.6	27.0	25.3	25.2					64.9	64.1	66.4	61.8
923	240-15-F	18.5	20.1	19.4	17.8					58.9	54.3	58.0	52.7
924	240-20-F	21.9	24.0	20.7	19.7					59.9	58.0	60.4	53.1
927	280-15-F	19.2	22.1	18.6	19.7					57.1	54.1	58.1	53.7
929	320-15-F	22.0	21.7	20.3	21.7					59.5	52.7	62.0	54.1

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.
PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Events of Stroke from Indicator Cards											
		Release, Per Cent. of Stroke				Beginning of Compression, Per Cent. of Stroke							
		Low Pressure Cylinder				High Pressure Cylinder				Low Pressure Cylinder			
		Right Side		Left Side		Right Side		Left Side		Right Side		Left Side	
		Head End	Crank End	Head End	Crank End	Head End	Crank End	Head End	Crank End	Head End	Crank End	Head End	Crank End
		280	281	282	283	284	285	286	287	288	289	290	291
901	80-15-F					45.1	39.0	46.6	39.1				
902	80-20-F					39.6	37.8	42.7	38.4				
904	80-25-F					36.2	31.8	38.2	32.5				
906	80-30-F					33.1	25.6	32.4	27.7				
908	120-20-F					40.3	36.6	42.7	36.9				
910	120-25-F					35.0	31.6	37.6	31.7				
912	120-30-F					32.4	34.3	32.3	30.2				
913	160-15-F					43.1	40.4	45.5	38.9				
914	160-20-F					41.8	38.0	43.1	37.6				
916	160-25-F					36.2	33.8	37.9	32.7				
917	160-27-F					32.3	29.7	35.2	28.5				
918	160-30-F					29.6	27.9	23.6	26.9				
920	200-20-F					41.5	35.9	42.1	37.7				
922	200-25-F					33.8	30.9	35.2	29.9				
923	240-15-F					45.9	36.9	43.9	39.4				
924	240-20-F					39.7	35.6	40.7	40.1				
927	280-15-F					44.6	38.9	42.7	39.5				
929	320-15-F					43.0	38.3	43.0	38.3				

Test Number	Laboratory Designation	Pressure from Indicator Cards								Factor of Evaporation
		Initial Pressures, Pounds Per Square Inch								
		High Pressure Cylinder				Low Pressure Cylinder				
		Right Side		Left Side		Right Side		Left Side		
		Head End	Crank End	Head End	Crank End	Head End	Crank End	Head End	Crank End	
		292	293	294	295	296	297	298	299	300
901	80-15-F	180.9	198.4	193.4	192.1					1.2261
902	80-20-F	182.7	195.7	190.6	193.4					1.2276
904	80-25-F	192.9	187.4	188.9	189.7					1.2257
906	80-30-F	198.0	198.6	198.0	202.4					1.2346
908	120-20-F	180.8	181.0	184.8	185.0					1.2256
910	120-25-F	182.7	183.1	188.1	186.0					1.2263
912	120-30-F	177.2	194.1	192.5	186.6					1.2324
913	160-15-F	176.5	195.9	188.2	178.2					1.2286
914	160-20-F	173.4	195.7	188.7	178.6					1.2310
916	160-25-F	176.6	196.6	191.6	181.6					1.2320
917	160-27-F	180.0	178.2	186.5	179.0					1.2257
918	160-30-F	173.5	176.5	180.8	180.8					1.2220
920	200-20-F	181.7	197.3	195.9	186.8					1.2318
922	200-25-F	179.8	196.1	190.3	181.1					1.2327
923	240-15-F	182.0	191.0	196.0	192.0					1.2330
924	240-20-F	178.6	182.1	188.4	191.3					1.2335
927	280-15-F	186.9	194.8	185.4	192.4					1.2325
929	320-15-F	197.5	190.8	200.8	190.8					

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.

PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Pressures from Indicator Cards: Steam Chest Pressures, Pounds Per Square Inch: High Pressure: Right Side	High Pressure: Left Side	Low Pressure: Right Side	Low Pressure: Left Side		Pressures at Cut-off, Pounds Per Square Inch: High Pressure Cylinder: Right Side: Head End	High Pressure Cylinder: Right Side: Crank End	High Pressure Cylinder: Left Side: Head End	High Pressure Cylinder: Left Side: Crank End
		301	302	303	304	305	306	307	308	309
901	80-15-F	198.3					148.8	169.4	164.5	163.2
902	80-20-F	196.7					158.1	165.4	167.7	166.4
904	80-25-F	196.5					166.9	171.6	156.4	170.3
906	80-30-F						173.8	176.1	174.2	178.2
908	120-20-F	197.2					154.4	152.7	151.5	164.0
910	120-25-F	196.3					148.3	159.1	154.7	161.6
912	120-30-F	198.6					146.0	164.1	156.1	168.5
913	160-15-F	198.0					123.8	145.9	135.0	136.9
914	160-20-F	202.0					124.1	146.1	128.8	127.3
916	160-25-F	202.0					127.5	146.0	135.9	138.4
917	160-27-F	187.2					131.7	130.2	136.0	138.9
918	160-30-F	185.5					125.2	137.8	135.4	141.1
920	200-20-F	197.1					121.2	145.6	129.8	129.5
922	200-25-F	203.0					123.4	139.0	134.1	125.8
923	240-15-F	—					115.0	126.0	127.0	128.0
924	240-20-F	—					108.8	126.7	127.1	133.4
927	280-15-F	—					109.3	118.9	115.3	115.9
929	320-15-F	—					106.7	112.5	112.9	113.3

Test Number	Laboratory Designation	Pressures from Indicator Cards: Pressures at Cut-off, Pounds Per Square Inch: Low Pressure Cylinder: Right Side: Head End	Low Pressure Cylinder: Right Side: Crank End	Low Pressure Cylinder: Left Side: Head End	Low Pressure Cylinder: Left Side: Crank End	Pressures at Release, Pounds Per Square Inch: High Pressure Cylinder: Right Side: Head End	High Pressure Cylinder: Right Side: Crank End	High Pressure Cylinder: Left Side: Head End	High Pressure Cylinder: Left Side: Crank End	Low Pressure Cylinder: Right Side: Head End	Low Pressure Cylinder: Right Side: Crank End	Low Pressure Cylinder: Left Side: Head End	Low Pressure Cylinder: Left Side: Crank End
		310	311	312	313	314	315	316	317	318	319	320	321
901	80-15-F					56.8	72.6	58.0	64.6				
902	80-20-F					61.0	71.6	59.6	69.1				
904	80-25-F					64.9	74.9	65.6	68.6				
906	80-30-F					85.2	92.0	80.7	90.1				
908	120-20-F					57.1	66.4	55.2	63.8				
910	120-25-F					63.2	71.7	64.2	71.4				
912	120-30-F					72.5	89.0	72.9	85.0				
913	160-15-F					48.8	61.3	50.5	55.6				
914	160-20-F					46.7	62.7	54.4	53.3				
916	160-25-F					55.4	71.8	58.9	63.0				
917	160-27-F					60.2	61.7	58.1	62.6				
918	160-30-F					61.0	69.3	60.8	66.0				
920	200-20-F					47.7	58.1	53.0	53.1				
922	200-25-F					54.9	64.4	56.1	57.5				
923	240-15-F					45.0	57.0	50.0	51.0				
924	240-20-F					48.3	59.3	51.3	56.9				
927	280-15-F					45.5	54.9	43.9	47.6				
929	320-15-F					46.7	53.3	42.4	50.0				

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No 5266.
PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Pressures from Indicator Cards. Pressures at Beginning of Compression, Pounds Per Square Inch. High Pressure Cylinder. Right Side. Head End	Crank End	Left Side. Head End	Crank End	Low Pressure Cylinder. Right Side. Head End	Crank End	Left Side. Head End	Crank End	Least Back Pressure, Pounds Per Square Inch. High Pressure Cylinder. Right Side. Head End	Crank End	Left Side. Head End	Crank End
		322	323	324	325	326	327	328	329	330	331	332	333
901	80-15-F	2.7	3.1	2.5	2.3					1.9	1.9	1.8	1.2
902	80-20-F	1.7	.9	2.8	1.9					1.1	.4	1.9	1.1
904	80-25-F	2.8	2.7	3.5	2.7					2.3	2.0	3.2	1.8
906	80-30-F	1.9	3.3	2.5	2.0					1.7	3.0	2.2	1.7
908	120-20-F	6.1	5.3	4.6	4.6					5.5	3.3	3.6	3.3
910	120-25-F	6.3	4.9	5.7	5.2					6.3	4.1	4.8	4.2
912	120-30-F	4.6	4.1	5.1	4.4					3.0	2.3	3.8	2.4
913	160-15-F	4.5	4.5	4.2	4.8					2.5	2.2	2.2	2.1
914	160-20-F	3.7	4.1	3.9	3.9					2.0	2.6	2.1	2.0
916	160-25-F	4.9	5.5	5.0	5.0					2.9	3.3	3.1	1.4
917	160-27-F	8.2	8.7	8.4	7.8					5.9	5.6	4.2	4.9
918	160-30-F	8.2	8.7	8.0	8.8					6.5	6.8	5.0	5.6
920	200-20-F	6.6	6.8	6.1	6.9					3.7	3.9	3.1	3.2
922	200-25-F	8.9	9.3	9.5	9.5					5.5	6.6	5.8	4.6
923	240-15-F	9.4	9.7	9.6	9.9					3.9	4.7	4.4	3.7
924	240-20-F	10.0	10.0	10.0	10.4					4.8	6.3	7.1	5.3
927	280-15-F	10.1	11.7	11.3	10.4					4.1	5.9	3.9	3.6
929	320-15-F	13.7	10.8	13.8	13.3					4.2	6.3	4.2	4.2

Test Number	Laboratory Designation	Pressures from Indicator Cards. Least Back Pressure, Pounds Per Sq. Inch. Low Pressure Cylinder. Right Side. Head End	Crank End	Left Side. Head End	Crank End	Boiler. Dry Coal Fired, Pounds. Per Hour	Per Sq. Ft. of Grate Surface	Evaporation, Pounds. Steam Per Hour. Moist	Dry	Dry, Per Sq. Ft. of Heating Surface	Dry Steam Per Pound of Dry Coal Fired
		334	335	336	337	338	339	340	341	342	343
901	80-15-F					1665	30.00	14673	14523	6.26	8.72
902	80-20-F					1934	34.85	16075	15922	6.87	8.23
904	80-25-F					2177	39.23	18512	18329	7.90	8.42
906	80-30-F					2932	52.83	22536	22290	9.61	7.60
908	120-20-F					2455	44.24	20135	19936	8.60	8.12
910	120-25-F					3333	60.04	23334	23102	9.96	6.93
912	120-30-F					3988	71.86	27711	27420	11.82	6.88
913	160-15-F					2729	49.17	20759	20559	8.86	7.53
914	160-20-F					2998	54.01	22040	21813	9.41	7.28
916	160-25-F					4221	76.05	26436	26174	11.29	6.20
917	160-27-F					4802	86.53	28670	28386	12.24	5.91
918	160-30-F					5581	100.58	30721	30417	13.11	5.45
920	200-20-F					3694	66.56	26113	25849	11.15	7.00
922	200-25-F					4983	89.78	30300	30000	12.93	6.02
923	240-15-F					5080	91.53	27365	27075	11.67	5.33
924	240-20-F					6101	109.93	28670	28386	12.24	4.65
927	280-15-F					5012	90.31	28890	28592	12.33	5.70
929	320-15-F					—	—	—	—	—	—

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.

PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Boiler							Engines			
		Equiv't Evap'n from and at 212° F., Pounds					Boiler Horse Power	Efficiency of Boiler	Mean Effective Pressure, Pounds Per Square Inch			
				Per Pound of					High Pressure Cylinder			
									Right Side		Left Side	
		Per Hour	Per Hour Per Sq. Ft. of Heat. Surface	Coal as Fired	Dry Coal as Fired	Com-bustible			Head End	Crank End	Head End	Crank End
		344	345	346	347	348	349	350	351	352	353	354
901	80-15-F	17806	7.68	10.40	10.69	11.31	516.0	67.65	55.70	67.50	59.20	59.83
902	80-20-F	19546	8.43	9.99	10.11	10.88	566.6	64.76	65.79	74.64	68.41	66.40
904	80-25-F	22466	9.69	10.21	10.32	10.98	651.1	65.71	86.90	86.30	81.60	83.07
906	80-30-F	27519	11.87	9.28	9.39	10.05	797.7	60.38	103.49	105.12	105.18	105.85
908	120-20-F	24434	10.54	9.85	9.95	10.58	708.2	63.36	67.70	68.90	63.20	64.70
910	120-25-F	28330	12.21	8.40	8.50	9.03	821.2	54.13	81.90	84.30	80.40	80.70
912	120-30-F	33792	14.68	8.36	8.47	9.05	979.4	54.32	90.61	104.80	95.76	99.36
913	160-15-F	25259	10.89	9.00	9.26	9.79	732.1	58.59	49.65	61.62	53.51	51.29
914	160-20-F	26851	11.58	8.70	8.96	9.46	778.3	56.68	53.36	68.56	59.44	57.17
916	160-25-F	32246	13.90	7.43	7.64	8.08	934.7	48.34	65.95	81.04	72.16	72.68
917	160-27-F	34793	15.00	7.17	7.25	7.70	1008.5	46.17	78.31	75.64	74.12	76.08
918	160-30-F	37170	16.03	6.59	6.66	7.08	1077.4	42.41	81.07	85.95	78.44	81.48
920	200-20-F	31841	13.73	8.38	8.62	9.11	922.9	54.52	54.83	64.26	58.84	57.20
922	200-25-F	36981	15.94	7.32	7.42	7.93	1071.9	47.59	66.33	77.33	70.90	67.81
923	240-15-F	33383	14.39	6.50	6.57	7.04	967.6	42.25	46.02	57.53	52.97	52.18
924	240-20-F	35014	15.10	5.68	5.74	6.15	1014.9	36.91	49.69	61.68	56.30	56.25
927	280-15-F	35240	15.19	6.95	7.03	7.53	1021.4	45.20	45.71	53.67	47.94	46.93
929	320-15-F	—	—	—	—	—	—	—	43.32	49.63	44.75	47.02

Test Number	Laboratory Designation	Engines									
		Mean Effective Pressure, Pounds Per Sq. Inch				Receiver		Number of Expansions			
		Low Pressure Cylinder				Pressure		Right Side		Left Side	
		Right Side		Left Side							
		Head End	Crank End	Head End	Crank End	Right Side	Left Side	Head End	Crank End	Head End	Crank End
		355	356	357	358	359	360	361	362	363	364
901	80-15-F							2.41	2.19	2.46	2.34
902	80-25-F							2.37	2.10	2.42	2.28
904	80-25-F							2.04	2.00	2.19	2.09
906	80-30-F							1.96	1.86	2.03	1.88
908	120-20-F							2.30	2.11	2.35	2.24
910	120-25-F							1.99	1.94	2.13	2.02
912	120-30-F							1.85	1.67	1.88	1.81
913	160-15-F							2.34	2.08	2.24	2.24
914	160-20-F							2.25	2.05	2.26	2.08
916	160-25-F							2.07	1.85	2.06	1.93
917	160-27-F							1.89	1.92	2.06	1.98
918	160-30-F							1.79	1.75	1.93	1.86
920	200-20-F							2.26	2.23	2.14	2.15
922	200-25-F							2.08	1.95	2.09	1.99
923	240-15-F							2.29	2.06	2.21	2.18
924	240-20-F							2.10	1.94	2.20	2.06
927	280-15-F							2.19	1.94	2.27	2.08
929	320-15-F							—	—	—	—

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.

PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Engines. Indicated Horse Power, High Pressure Cylinder, Right Side, Head End	Engines. Indicated Horse Power, High Pressure Cylinder, Right Side, Crank End	Engines. Indicated Horse Power, High Pressure Cylinder, Left Side, Head End	Engines. Indicated Horse Power, High Pressure Cylinder, Left Side, Crank End	Engines. Indicated Horse Power, Low Pressure Cylinder, Right Side, Head End	Engines. Indicated Horse Power, Low Pressure Cylinder, Right Side, Crank End	Engines. Indicated Horse Power, Low Pressure Cylinder, Left Side, Head End	Engines. Indicated Horse Power, Low Pressure Cylinder, Left Side, Crank End	Division of Power, High Pressure Cylinder, Right Side	Division of Power, High Pressure Cylinder, Left Side	Division of Power, Low Pressure Cylinder, Right Side	Division of Power, Low Pressure Cylinder, Left Side
		365	366	367	368	369	370	371	372	373	374	375	376
901	80-15-F	96.6	113.7	105.7	103.8					210.3	209.5		
902	80-20-F	114.1	125.8	122.1	115.2					239.9	237.3		
904	80-25-F	150.7	145.4	145.4	144.1					296.1	289.5		
906	80-30-F	179.5	177.1	187.7	183.6					356.6	371.3		
908	120-20-F	176.0	174.1	169.2	168.3					350.1	337.5		
910	120-25-F	213.0	213.0	215.2	209.9					426.0	425.1		
912	120-30-F	235.7	264.8	256.4	258.5					500.5	514.9		
913	160-15-F	172.3	207.6	191.0	177.9					379.9	368.9		
914	160-20-F	185.1	231.1	212.2	198.4					416.2	410.6		
916	160-25-F	228.8	273.1	257.6	252.1					501.9	509.7		
917	160-27-F	271.6	254.9	264.6	263.9					526.5	528.5		
918	160-30-F	281.2	289.6	279.9	282.6					570.8	562.6		
920	200-20-F	237.4	270.7	262.5	248.0					508.1	510.5		
922	200-25-F	287.6	325.7	316.4	294.0					613.3	610.4		
923	240-15-F	239.5	290.8	283.6	271.5					530.3	555.1		
924	240-20-F	258.5	311.8	301.5	292.7					570.3	594.2		
927	280-15-F	277.5	316.5	299.5	284.9					594.0	584.4		
929	320-15-F	300.7	334.6	319.6	326.4					635.3	646.0		

Test Number	Laboratory Designation	Engines. Division of Power, Total, Right Side	Engines. Division of Power, Total, Left Side	Engines. Division of Power, Total I. H. P.	Engines. Consumed Per I. H. P., Per Hour, Dry Coal, Pounds	Engines. Consumed Per I. H. P., Per Hour, Dry Steam, Pounds	Engines. Consumed Per I. H. P., Per Hour, B. T. U.	Locomotive. Dynamometer Horse Power	Locomotive. Pounds Per D. H. P., Per Hour, Of Dry Coal	Locomotive. Pounds Per D. H. P., Per Hour, Of Dry Steam	Locomotive. B. T. U. Per D. H. P., Per Hour
		377	378	379	380	381	382	383	384	385	386
901	80-15-F	210.3	209.5	419.8	3.97	33.54	60598	327.3	5.09	43.02	77693
902	80-20-F	239.9	237.3	477.2	4.05	32.27	61069	389.8	4.96	39.50	74782
904	80-25-F	296.1	289.5	585.6	3.72	30.65	56480	499.6	4.36	35.92	66128
906	80-30-F	356.6	371.3	727.9	4.03	29.94	60531	632.3	4.64	34.46	69693
908	120-20-F	350.1	337.5	687.6	3.57	28.81	54160	556.2	4.42	35.16	67040
910	120-25-F	426.0	425.1	851.1	3.92	26.70	59450	721.1	4.62	31.51	70070
912	120-30-F	500.5	514.9	1015.4	3.93	26.63	59174	900.8	4.43	29.59	66702
913	160-15-F	379.9	368.9	748.8	3.64	26.75	55560	568.2	4.80	35.26	73267
914	160-20-F	416.2	410.6	826.8	3.63	25.34	55408	665.9	4.50	31.46	68680
916	160-25-F	501.9	509.7	1011.6	4.17	25.23	63650	830.7	5.08	30.73	77541
917	160-27-F	526.5	528.5	1055.0	4.55	26.50	68964	892.1	5.38	31.34	81640
918	160-30-F	570.8	562.6	1133.4	4.92	26.46	74622	975.0	5.72	30.83	86750
920	200-20-F	508.1	510.5	1018.6	3.63	24.83	55410	789.4	4.68	32.04	71435
922	200-25-F	613.3	610.4	1223.7	4.07	23.84	61280	980.6	5.08	29.75	76480
923	240-15-F	530.3	555.1	1085.4	4.68	24.60	70294	880.7	5.77	30.31	86665
924	240-20-F	570.3	594.2	1164.5	5.24	24.37	78705	902.8	6.76	31.43	101535
927	280-15-F	594.0	584.4	1178.4	4.25	23.81	63835	847.2	5.92	33.12	88918
929	320-15-F	635.3	646.0	1281.3	—	—	—	896.9	—	—	—

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.

PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Locomotive: Per One Million Foot Pounds at Draw-Bar: Dry Coal, Pounds	Dry Steam, Pounds	B. T. U.	I. H. P., Per Square Foot of: Heating Surface	Grate Surface	D. H. P. Per Square Foot of: Heating Surface	Grate Surface	Tractive Power Based on M. E. P., Pounds	Machine Friction of Locomotive, in Terms of: Horse Power	M. E. P., Pounds	Draw-Bar Pull, Pounds
		387	388	389	390	391	392	393	394	395	396	397
901	80-15-F	2.57	21.73	39220	.181	7.56	.141	5.90	8240	92.5	13.34	1816
902	80-20-F	2.51	19.94	37843	.206	8.60	.168	7.02	9368	87.4	12.57	1716
904	80-25-F	2.20	18.15	33370	.253	10.55	.215	9.00	11510	86.0	12.40	1689
906	80-30-F	2.34	17.40	35147	.314	13.12	.273	11.39	14360	95.6	13.78	1886
908	120-20-F	2.23	17.74	33820	.296	12.39	.240	10.02	9000	131.4	12.63	1652
910	120-25-F	2.36	15.91	35799	.367	15.33	.311	12.99	11138	130.1	12.50	1702
912	120-30-F	2.24	14.95	33727	.438	18.29	.388	16.23	13291	114.6	11.01	1499
913	160-15-F	2.43	17.81	37091	.323	13.49	.245	10.23	7350	180.6	13.01	1417
914	160-20-F	2.27	15.88	34640	.357	14.90	.287	12.00	8115	160.9	11.60	1579
916	160-25-F	2.58	15.53	39230	.436	18.22	.358	14.97	9929	180.9	13.03	1775
917	160-27-F	2.72	15.83	41255	.455	19.01	.385	16.07	10354	162.9	11.74	1599
918	160-30-F	2.89	15.58	43860	.489	20.42	.420	17.57	11126	158.4	11.41	1554
920	200-20-F	3.63	16.18	55408	.439	18.35	.340	14.22	8000	229.2	13.21	1805
922	200-25-F	2.57	15.03	38698	.528	22.04	.423	17.66	9610	243.1	14.01	1909
923	240-15-F	3.40	17.86	51068	.468	19.56	.380	15.87	7103	204.7	8.43	1148
924	240-20-F	3.41	15.88	51218	.502	20.98	.389	16.27	7621	261.7	12.57	1713
927	280-15-F	2.99	16.73	44910	.508	21.23	.365	15.26	6610	331.2	13.64	1858
929	320-15-F	—	—	—	—	—	—	—	6316	—	—	—

Test Number	Laboratory Designation	Locomotive: Machine Efficienc of Locomotive, Per Cent	Efficiency of Locomotive, Per Cent.	Ratios: Total Weight of Locomotive to Maximum I. H. P.	Total Heating Surface to Maximum I. H. P.	Millions of Foot Lbs. at Draw-Bar Per Hour	Maximum I. H. P.				Date of Test
		398	399	400	401	402	403	404	405	406	407
901	80-15-F	77.96	3.28		5.39	648	429.7				12-28-06
902	80-20-F	81.68	3.40		4.66	772	497.7				1-15-07
904	80-25-F	85.35	3.85		3.73	989	622.2				11-20-06
906	80-30-F	86.87	3.65		3.07	1252	756.3				3- 4-07
908	120-20-F	80.89	3.79		3.26	1102	711.9				11-21-06
910	120-25-F	84.71	3.63		2.67	1427	867.8				11-22-06
912	120-30-F	88.71	3.82		2.21	1783	1048.5				12-15-06
913	160-15-F	75.88	3.47		3.05	1125	759.8				1- 3-07
914	160-20-F	80.54	3.71		2.75	1319	843.0				12-18-06
916	160-25-F	82.11	3.28		2.26	1644	1028.5				12-19-06
917	160-27-F	84.56	3.18		2.07	1766	1120.1				11-28-06
918	160-30-F	86.02	2.93		1.99	1930	1160.7				11-26-06
920	200-20-F	77.49	3.56		2.20	1563	1053.5				12-20-06
922	200-25-F	80.13	3.33		1.86	1941	1247.8				12-12-06
923	240-15-F	81.14	2.94		1.76	1495	1319.7				2-20-07
924	240-20-F	77.53	2.51		1.95	1787	1191.2				2-16-07
927	280-15-F	71.89	2.86		1.85	1677	1251.0				2-21-07
929	320-15-F	70.00	—		—	—	—				3- 7-07

SUMMARY OF AVERAGE RESULTS—LOCOMOTIVE No. 5266.

PENNSYLVANIA RAILROAD COMPANY.

Test Number	Laboratory Designation	Duration of Test Hours	Revolutions Per Minute	Equivalent Miles Per Hour	Approximate Cut-off, Per Cent. of Stroke, High Pressure Cylinder	Position of Throttle	Boiler Pressure, Lbs. Per Sq. In.	Br. Pipe Pressure Lbs. Per Sq. In.	Draft, Front of Diaphragm, Inches of Water	Dry Coal Fired Per Hour, Pounds	Dry Steam Used Per Hour, Pounds
		196	198	199	268 to 271	203	217	220	222	338	341
901	80-15-F	3.00	80.00	19.10	15.7	Full	201.3	198.3	2.0	1665	14523
902	80-20-F	3.00	80.00	19.10	17.9	Full	200.1	197.3	2.1	1934	15922
904	80-25-F	3.00	79.99	19.09	23.7	Full	198.5	192.8	3.3	2177	18329
906	80-30-F	3.00	80.00	19.01	29.7	Full	202.6	199.8	3.4	2932	22290
908	120-20-F	3.00	120.00	28.65	18.8	Full	201.0	197.7	3.9	2455	19936
910	120-25-F	3.00	120.00	28.65	24.9	Full	200.5	197.5	5.1	3333	23102
912	120-30-F	2.50	120.00	28.65	31.7	Full	202.7	197.8	4.9	3988	27420
913	160-15-F	3.00	160.00	38.20	16.7	Full	198.0	195.0	3.1	2729	20559
914	160-20-F	3.00	160.00	38.20	20.2	Full	202.9	198.2	3.7	2998	21813
916	160-25-F	2.50	160.00	38.20	24.9	Full	200.0	195.0	5.2	4221	26174
917	160-27-F	3.00	160.00	38.20	27.7	Full	188.4	185.6	7.7	4802	28386
918	160-30 F	1.00	160.00	38.20	31.5	Full	186.1	181.8	8.9	5581	30417
920	200-20-F	2.50	200.00	47.75	19.5	Full	202.0	197.4	5.0	3694	25849
922	200-25-F	1.20	200.00	47.75	25.5	Full	202.1	197.1	6.0	4983	30000
923	240-15-F	1.50	240.00	57.30	19.0	Full	196.4	194.2	5.6	5080	27075
924	240-20-F	1.00	240.00	57.30	21.6	Full	197.5	195.1	5.4	6101	28386
927	280-15-F	1.00	280.00	66.85	19.9	Full	194.4	191.7	5.6	5012	28592
929	320-15-F	——	320.17	76.08	21.4	Full	196.3	——	——	——	——

Test Number	Laboratory Designation	Equivalent Lbs Water Per Lb. Coal from and at 212° F	Indicated Horse Power	Dynamometer Horse Power	Frictional Horse Power	Draw-Bar Pull, Pounds	Dry Coal Per I. H. P. Per Hour, Pounds	Dry Coal Per D. H. P. Per Hour, Pounds	Dry Steam Per I. H. P. Per Hour, Pounds	Dry Steam Per D. H. P. Per Hour, Pounds	Efficiency of Boiler	Efficiency of Locomotive
		347	379	383	395	265	380	384	381	385	350	399
901	80-15-F	10.69	419.8	327.3	92.5	6427	3.97	5.09	33.54	43.02	67.65	3.28
902	80-20-F	10.11	477.2	389.8	87.4	7653	4.05	4.96	32.27	39.50	64.76	3.40
904	80-25-F	10.32	585.6	499.6	86.0	9810	3.72	4.36	30.65	35.92	65.71	3.85
906	80-30-F	9.39	727.9	632.3	95.6	12475	4.03	4.64	29.94	34.46	60.38	3.65
908	120-20-F	9.95	687.6	556.2	131.4	7280	3.57	4.42	28.81	35.16	63.36	3.79
910	120-25-F	8.50	851.1	721.1	130.1	9438	3.92	4.62	26.70	31.51	54.13	3.63
912	120-30-F	8.47	1015.4	900.8	114.6	11785	3.93	4.43	26.63	29.59	54.32	3.82
913	160-15-F	9.26	748.8	568.2	180.6	5578	3.64	4.80	26.75	35.26	58.59	3.47
914	160-20-F	8.96	826.8	665.9	160.9	6538	3.63	4.50	25.34	31.46	56.68	3.71
916	160-25-F	7.64	1011.6	830.7	180.9	8155	4.17	5.08	25.23	30.73	48.34	3.28
917	160-27-F	7.25	1055.0	892.1	162.9	8757	4.55	5.38	26.50	31.34	46.17	3.18
918	160-30-F	6.66	1133.4	975.0	158.4	9571	4.92	5.72	26.46	30.83	42.41	2.93
920	200-20-F	8.62	1018.6	789.4	229.2	6199	3.63	4.68	24.83	32.04	54.52	3.56
922	200-25-F	7.42	1223.7	980.6	243.1	7701	4.07	5.08	23.84	29.75	47.59	3.33
923	240-15-F	6.57	1085.4	880.7	204.2	4940	4.68	5.77	24.60	30.31	42.25	2.94
924	240-20-F	5.74	1164.5	902.8	261.7	5908	5.24	6.76	24.37	31.43	36.91	2.51
927	280-15-F	7.03	1178.4	847.2	331.2	4752	4.25	5.92	23.81	33.12	45.20	2.86
929	320-15-F	——	1281.3	896.9	384.4	4424	——	——	——	——	——	——

GRAPHICAL LOG OF LOCOMOTIVE TEST

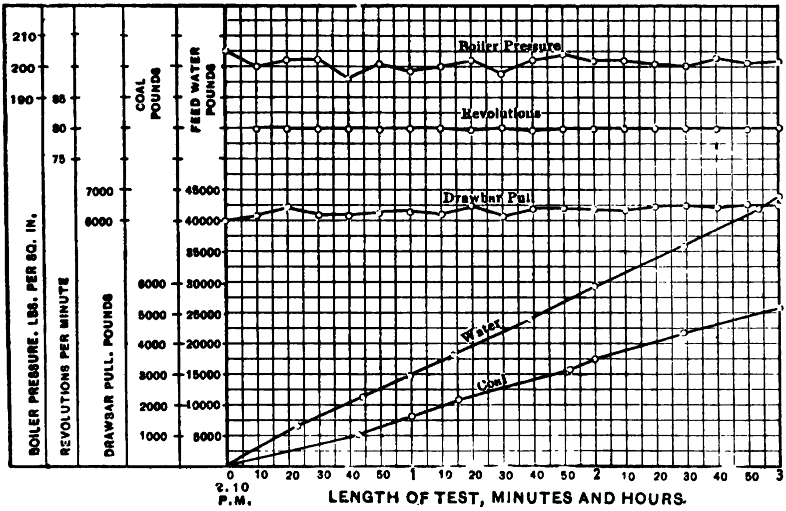
LOCOMOTIVE — TEST NO. 901

TYPE 4-4-2 — R.P.M. 80, CUT-OFF 15, THROTTLE F

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 12-28-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

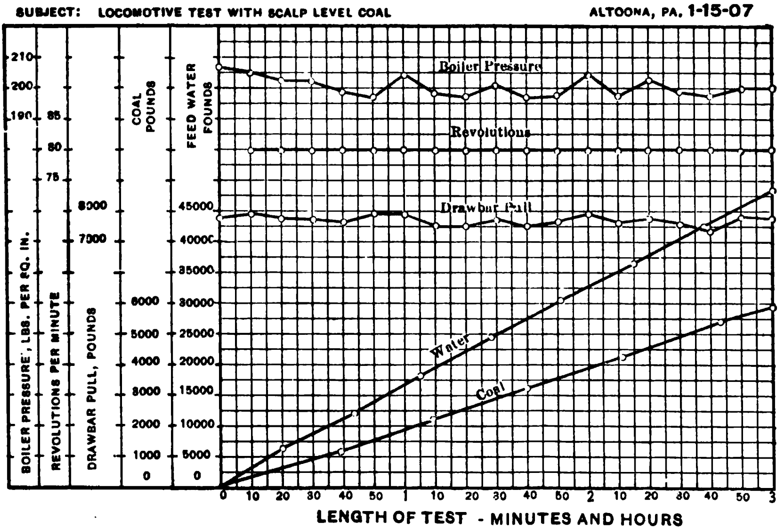
LOCOMOTIVE — TEST NO. 902

TYPE 4-4-2 — R.P.M. 80, CUT-OFF 20, THROTTLE F

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 1-15-07



GRAPHICAL LOG OF LOCOMOTIVE TEST

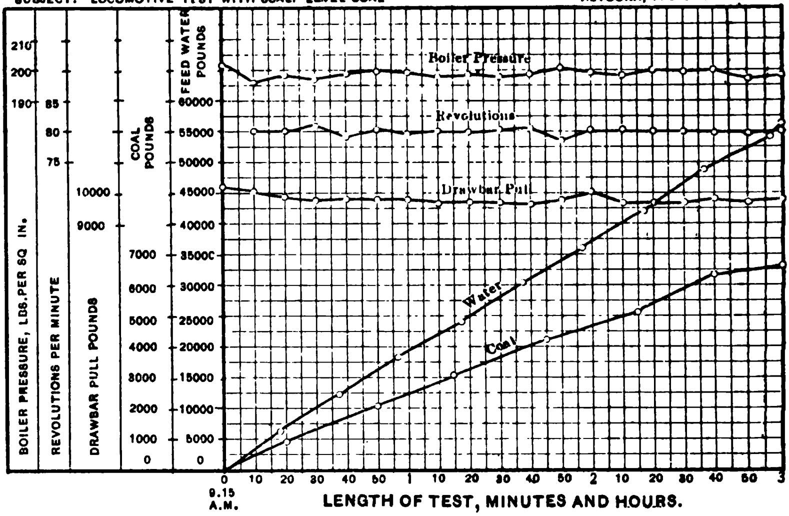
LOCOMOTIVE — TEST NO. 904

TYPE 4-4-2 — R.P.M. 80 — CUT-OFF 25 — THROTTLE F.

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 11-20-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

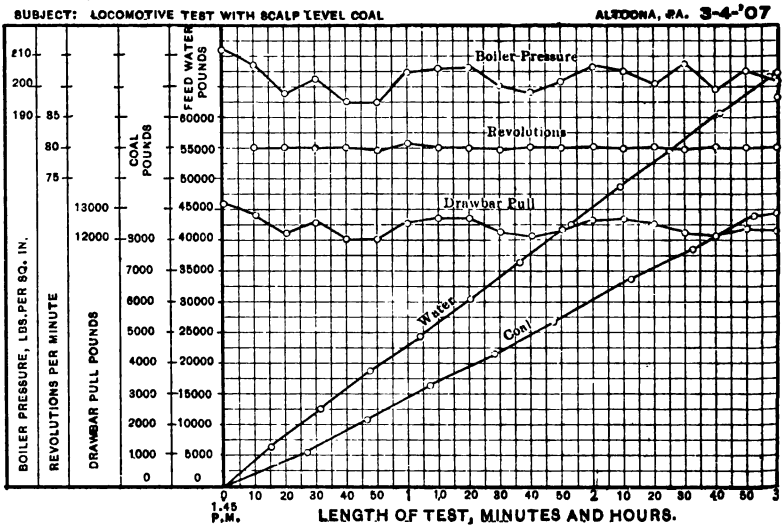
LOCOMOTIVE — TEST NO. 906

TYPE 4-4-2 — R.P.M. 80 — CUT-OFF 30 — THROTTLE F.

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 3-4-'07



GRAPHICAL LOG OF LOCOMOTIVE TEST

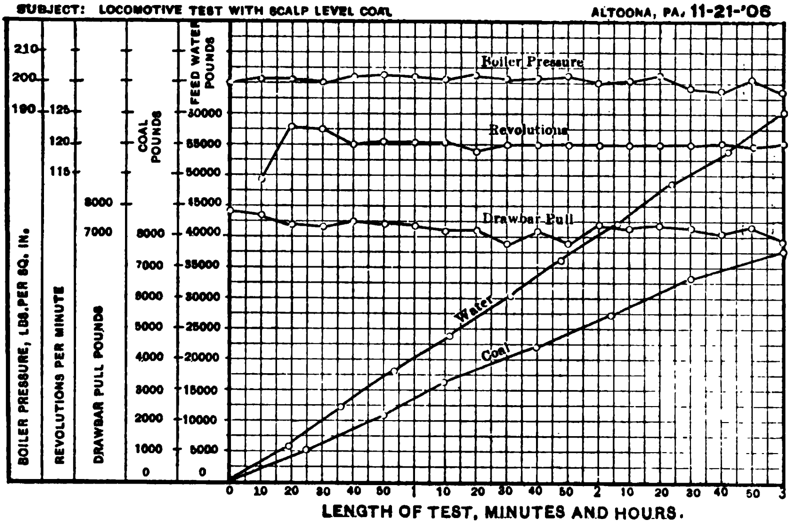
LOCOMOTIVE — TEST NO. 908

TYPE 4-4-2 — R.P.M. 120, CUT-OFF 20, THROTTLE F.

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 11-21-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

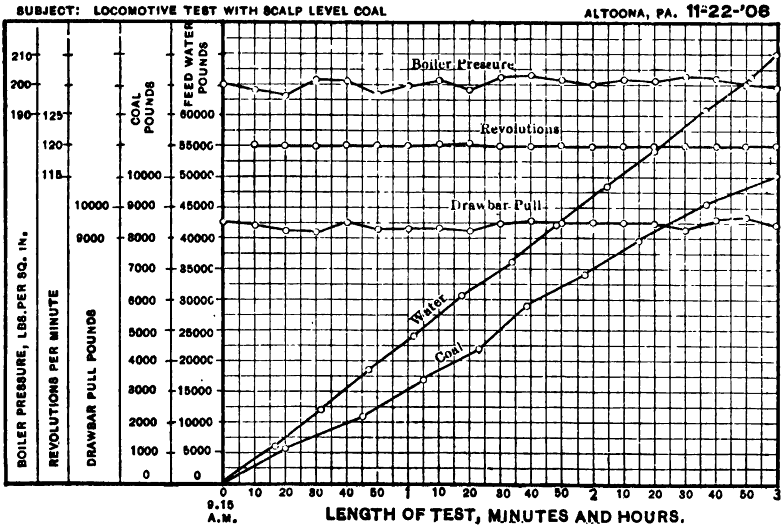
LOCOMOTIVE — TEST NO. 910

TYPE 4-4-2 — R.P.M. 120, CUT-OFF 25, THROTTLE F.

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 11-22-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

LOCOMOTIVE

TYPE 4-4-2

CLASS E 2 A

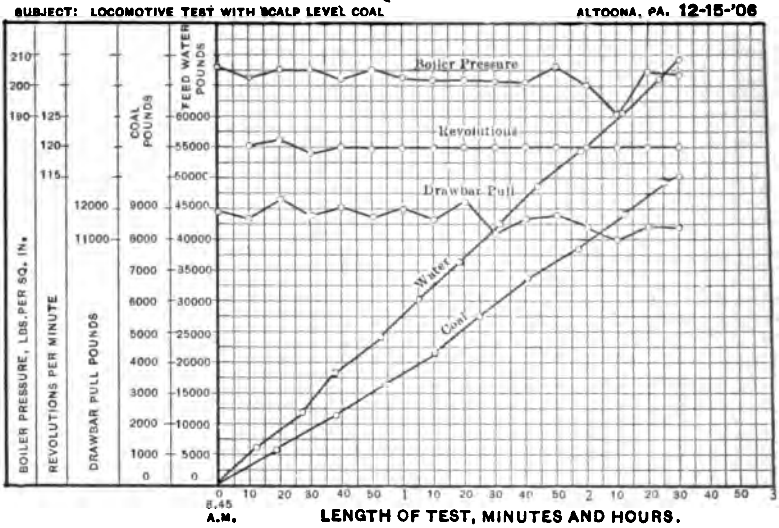
NUMBER 5266

TEST NO. 912

R.P.M. 120 | CUT-OFF 30 | THROTTLE F.

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL

ALTOONA, PA. 12-15-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

LOCOMOTIVE

TYPE 4-4-2

CLASS E 2 A

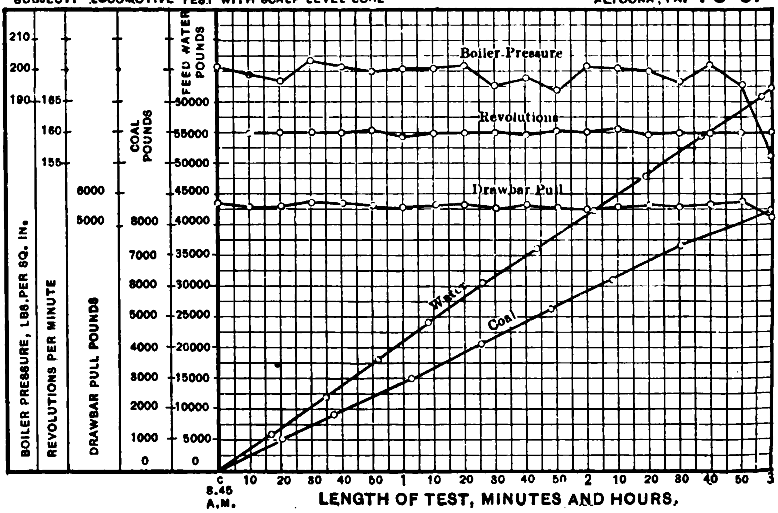
NUMBER 5266

TEST NO. 913

R.P.M. 160 | CUT-OFF 15 | THROTTLE F.

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL

ALTOONA, PA. 1-3-'07



GRAPHICAL LOG OF LOCOMOTIVE TEST

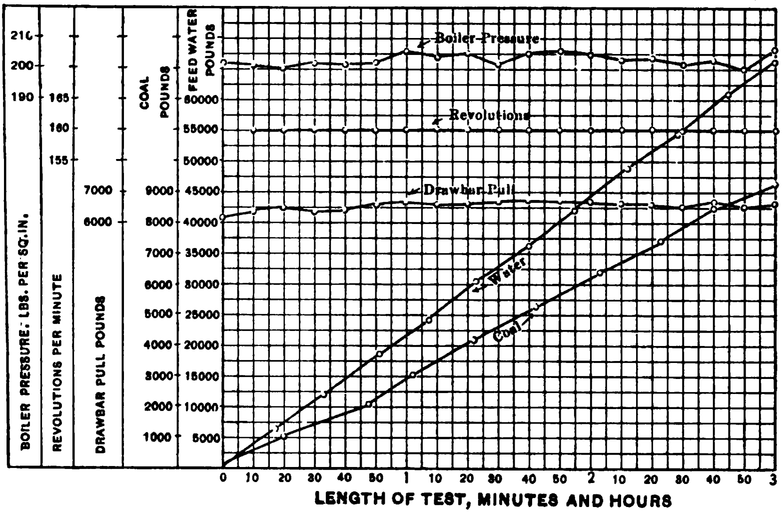
LOCOMOTIVE — TEST NO. 914

TYPE 4-4-2 — R.P.M. 160, CUT-OFF 20, THROTTLE F

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA PA. 12-18-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

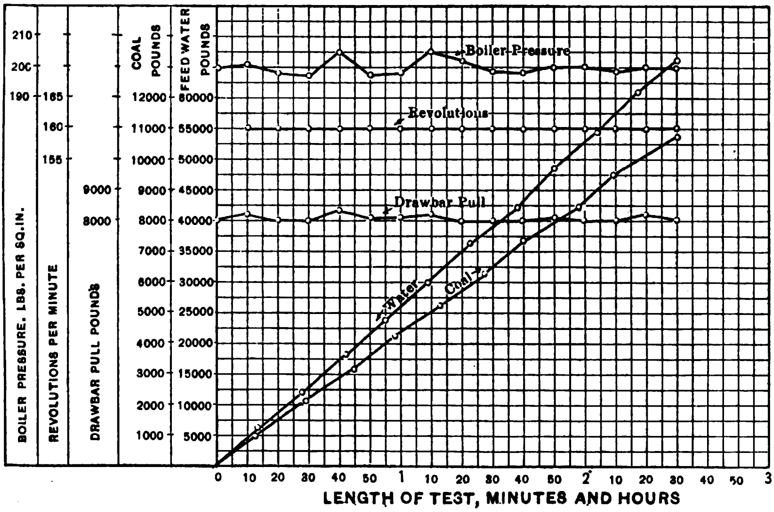
LOCOMOTIVE — TEST NO. 916

TYPE 4-4-2 — R.P.M. 160, CUT-OFF 25, THROTTLE F

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA PA. 12-19-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

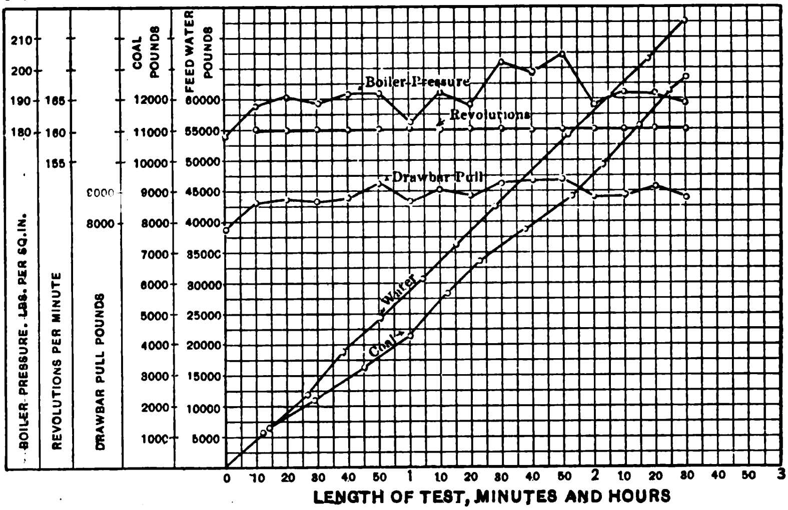
LOCOMOTIVE — TEST NO. 917

TYPE 4-4-2 — R.P.M. 160 — CUT-OFF 27 — THROTTLE F

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA PA. NOV.-28-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

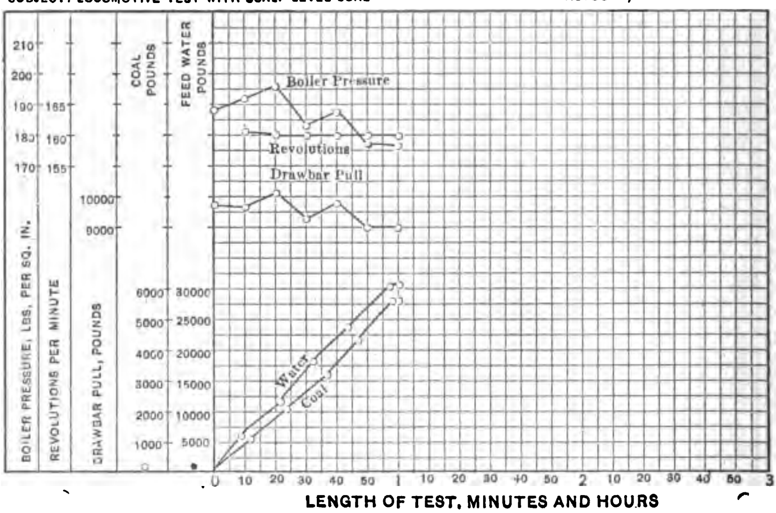
LOCOMOTIVE — TEST NO. 918

TYPE 4-4-2 — R.P.M. 160 — CUT-OFF 30 — THROTTLE F

CLASS E 2 A

NUMBER 5266

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 11-28-'06



GRAPHICAL LOG OF LOCOMOTIVE TEST

LOCOMOTIVE

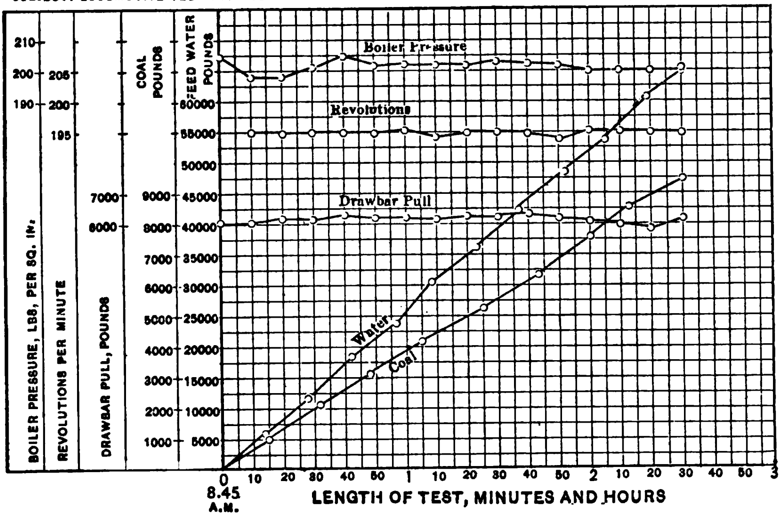
TYPE **4-4-2**
CLASS **E 2 A**
NUMBER **5266**

TEST NO **920**

R.P.M.	CUT-OFF	THROTTLE
200	20	F

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL

ALTOONA, PA. **12-20-'06**



GRAPHICAL LOG OF LOCOMOTIVE TEST

LOCOMOTIVE

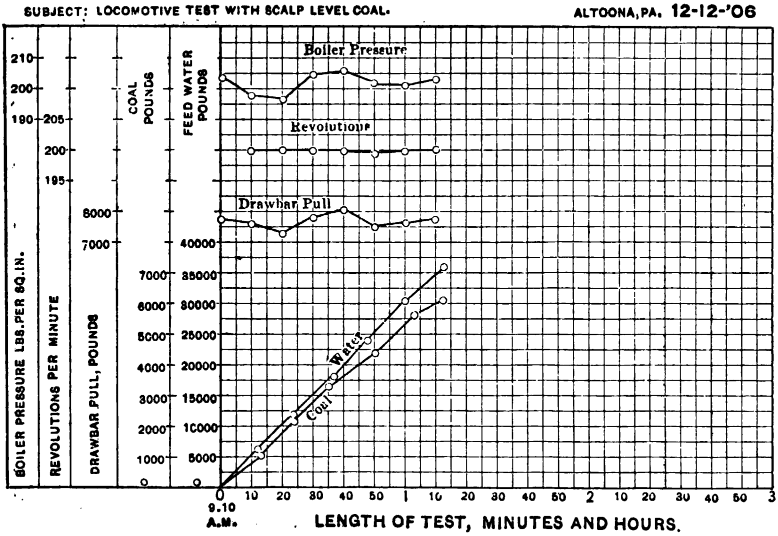
TYPE **4-4-2**
CLASS **E 2 A**
NUMBER **5266**

TEST NO. **922**

R P.M.	CUT-OFF	THROTTLE
200	25	F

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL.

ALTOONA, PA. **12-12-'06**



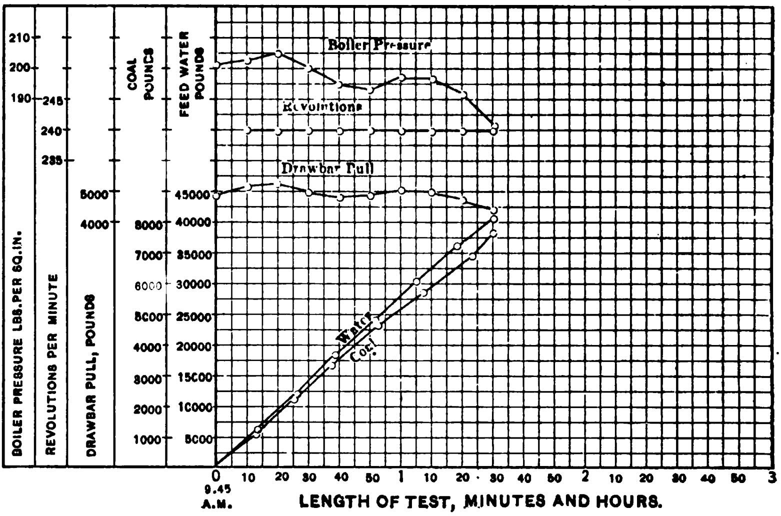
GRAPHICAL LOG OF LOCOMOTIVE TEST

LOCOMOTIVE
TYPE 4-4-2
CLASS E 2 A
NUMBER 5266

TEST NO. 923
R.P.M. CUT-OFF THROTTLE
240 15 F

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL.

ALTOONA, PA. 2-20-'07



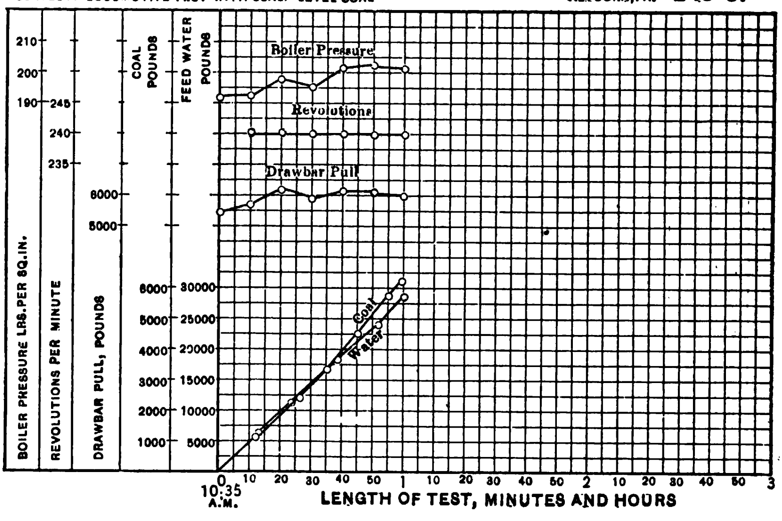
GRAPHICAL LOG OF LOCOMOTIVE TEST

LOCOMOTIVE
TYPE 4-4-2
CLASS E 2 A
NUMBER 5266

TEST NO. 924
R.P.M. CUT-OFF THROTTLE
240 20 F

SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL

ALTOONA, PA. 2-16-'07



GRAPHICAL LOG OF LOCOMOTIVE TEST

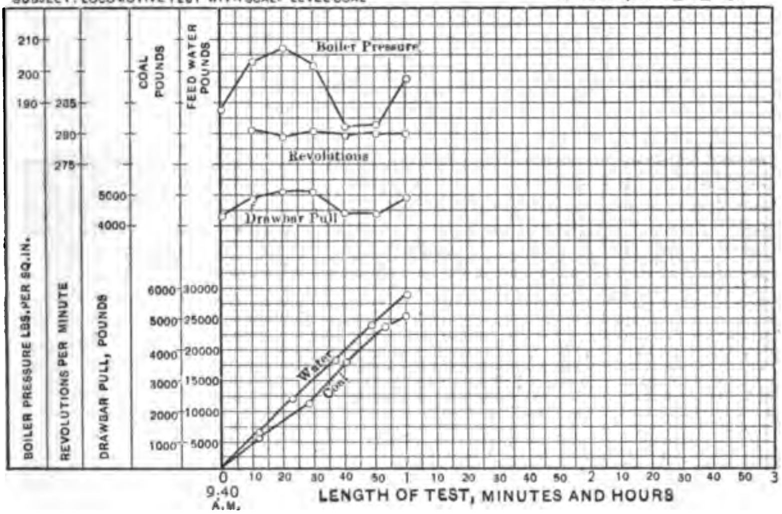
LOCOMOTIVE — TEST NO. 927

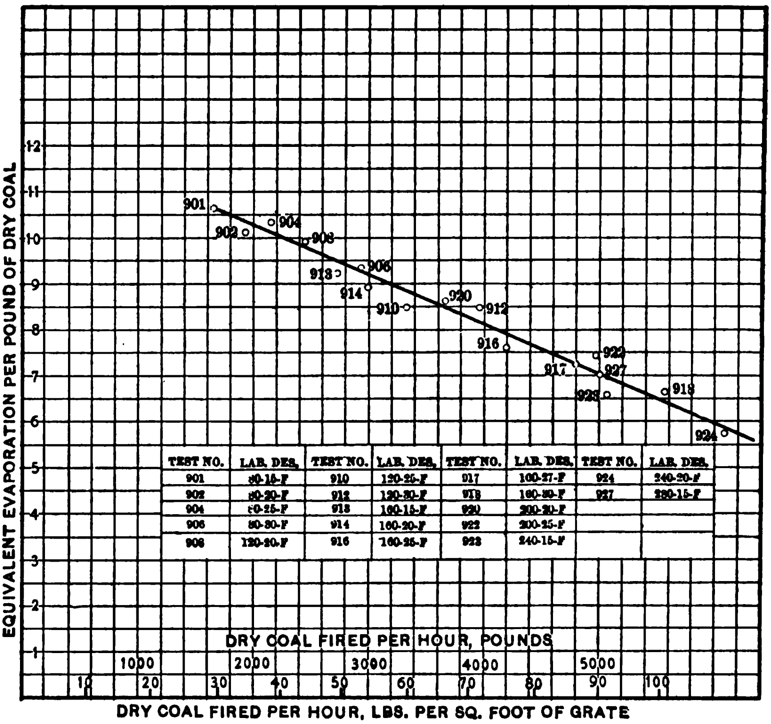
TYPE 4-4-2 — R.P.M. 280, CUT-OFF 15, THROTTLE F

CLASS E 2 A

NUMBER 5266

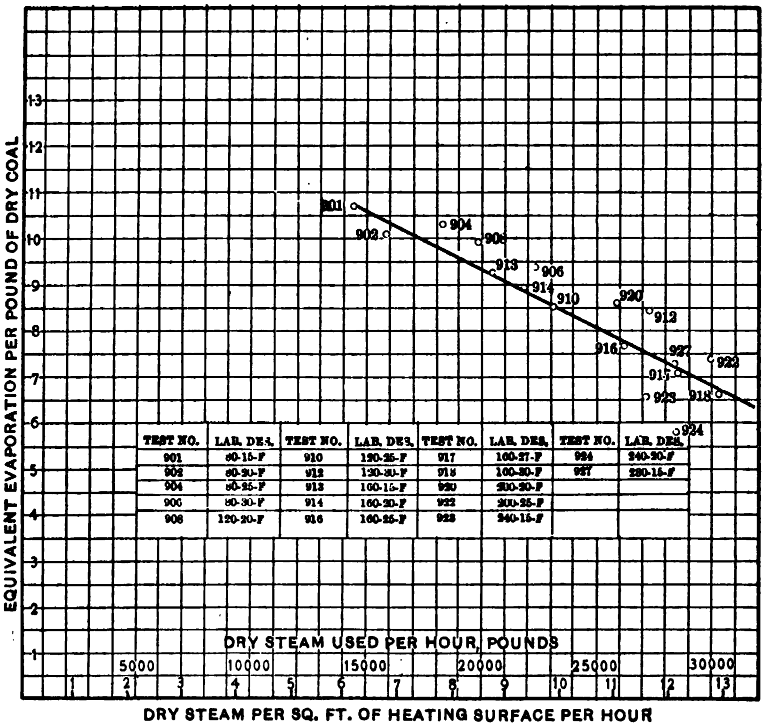
SUBJECT: LOCOMOTIVE TEST WITH SCALP LEVEL COAL — ALTOONA, PA. 2-12-'07





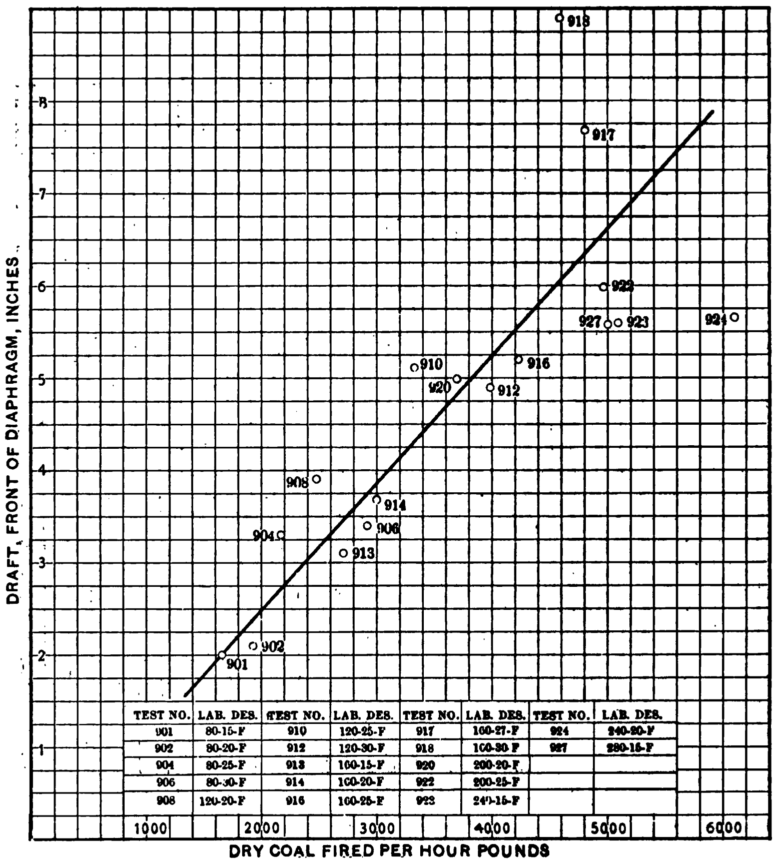
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	100-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 901.



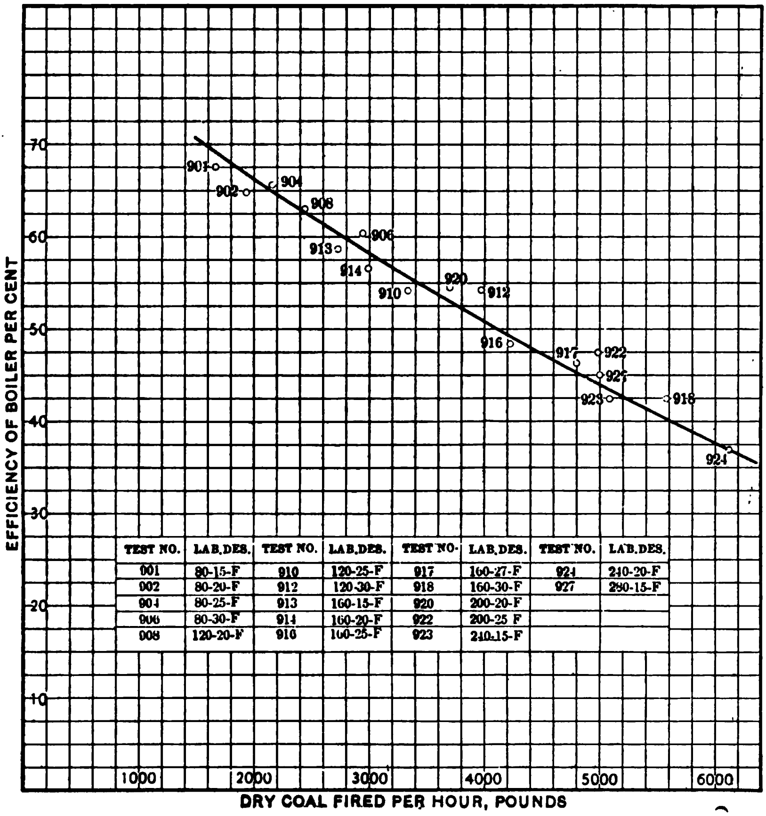
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 902.



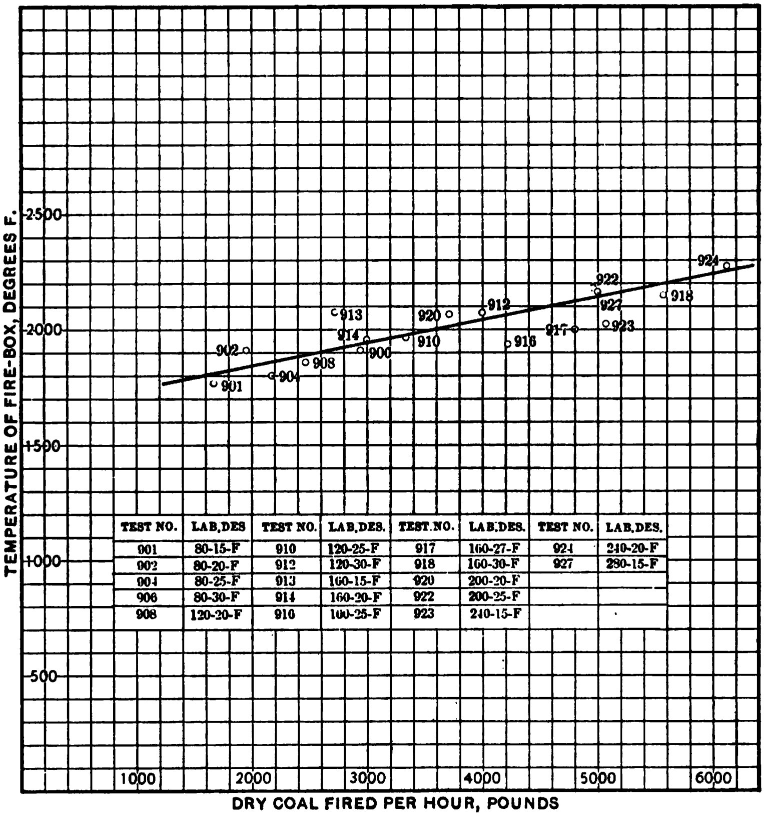
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 903.



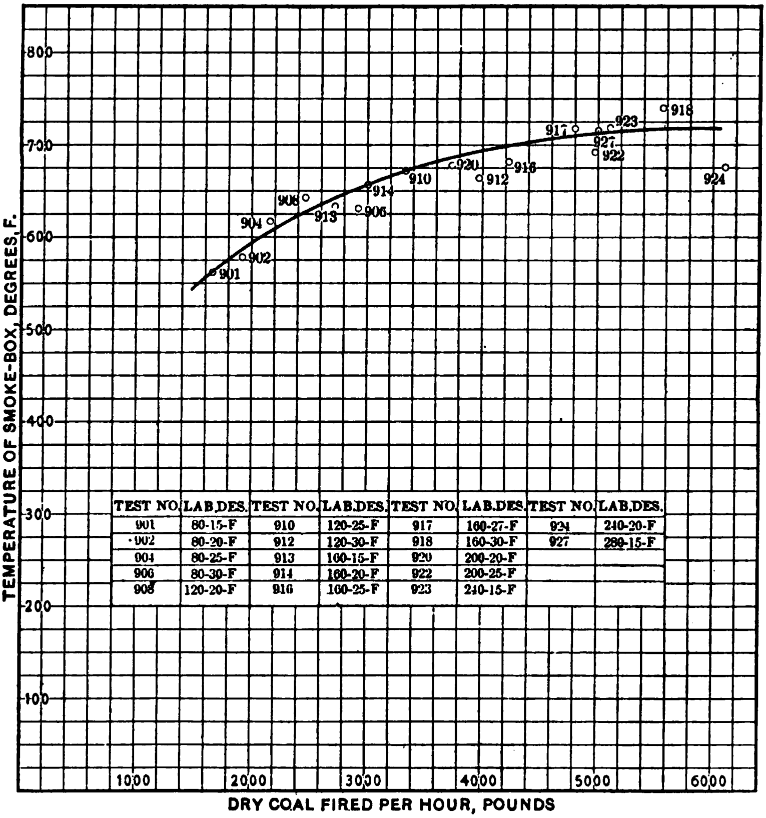
TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25 F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 904.



TEST NO.	LAB.DES	TEST NO.	LAB.DES.	TEST.NO.	LAB.DES.	TEST NO.	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

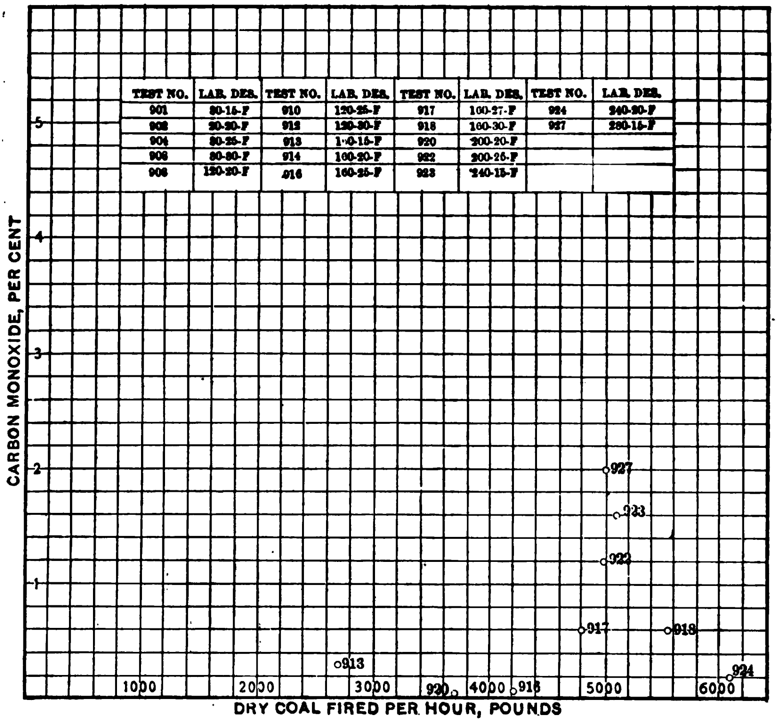
PLOT No. 905.



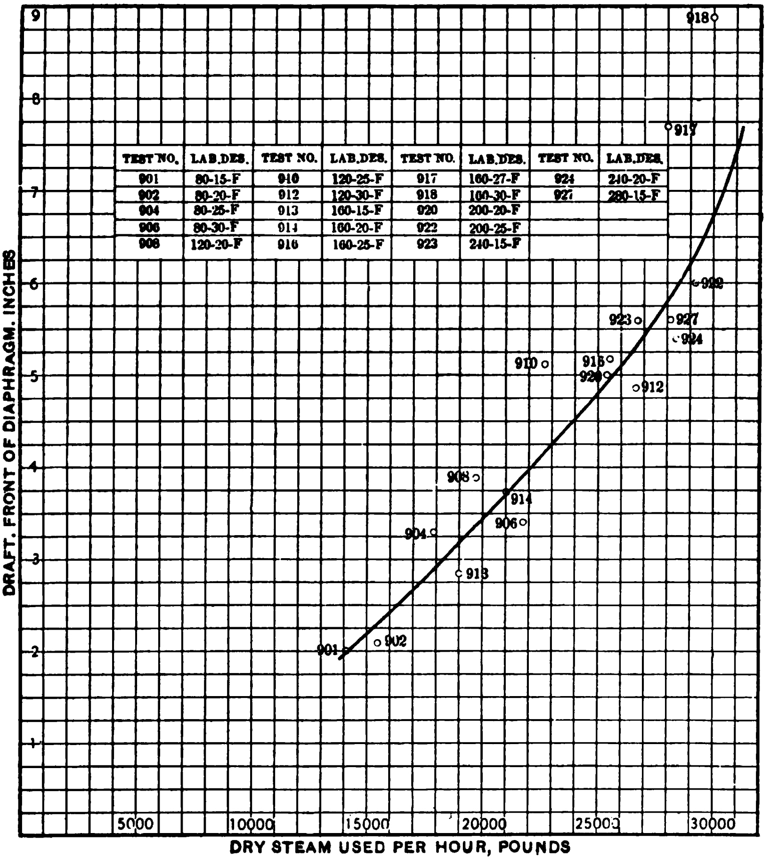
TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 906.

TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	140-15-F	920	200-20-F		
905	80-30-F	914	160-20-F	922	200-25-F		
906	120-20-F	916	160-25-F	923	240-15-F		

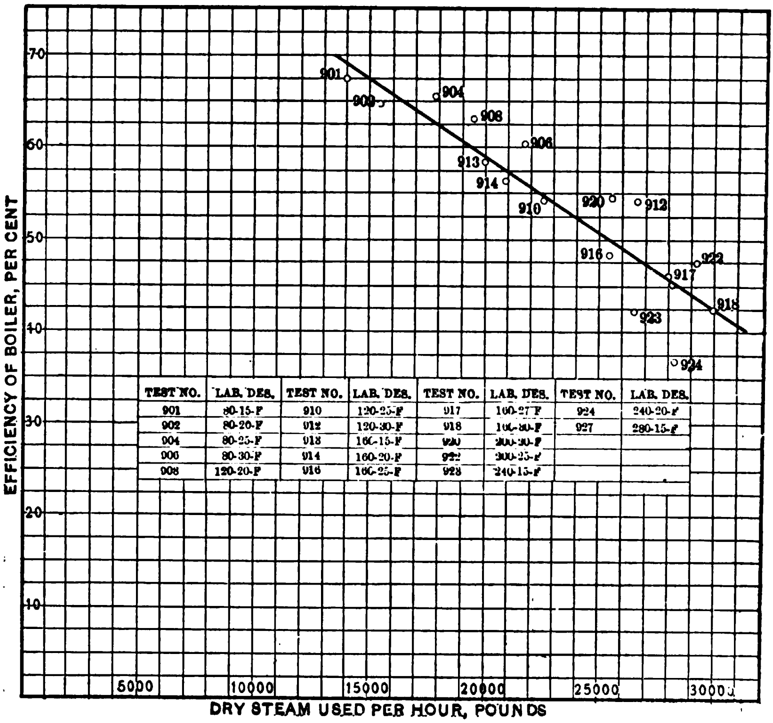


PLOT No. 907.



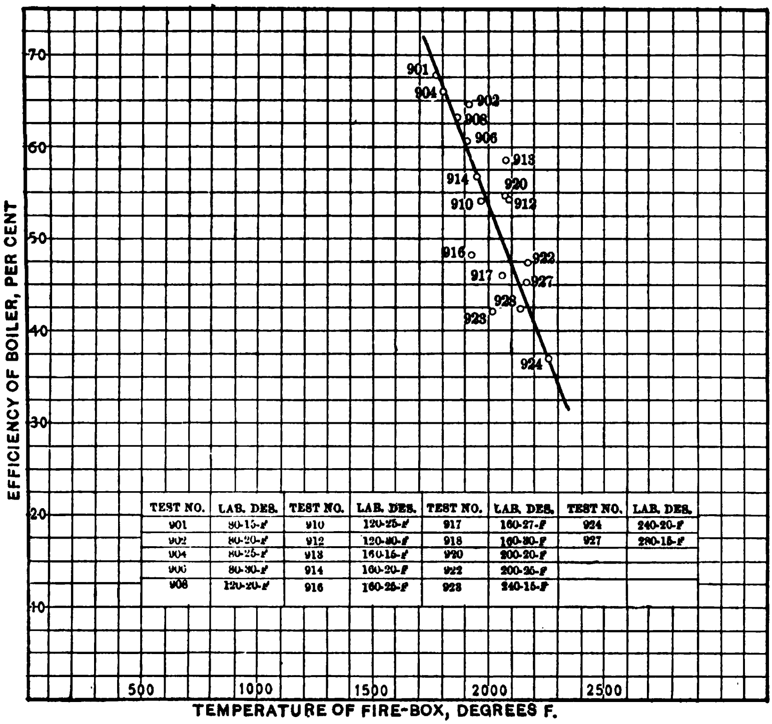
TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 908.



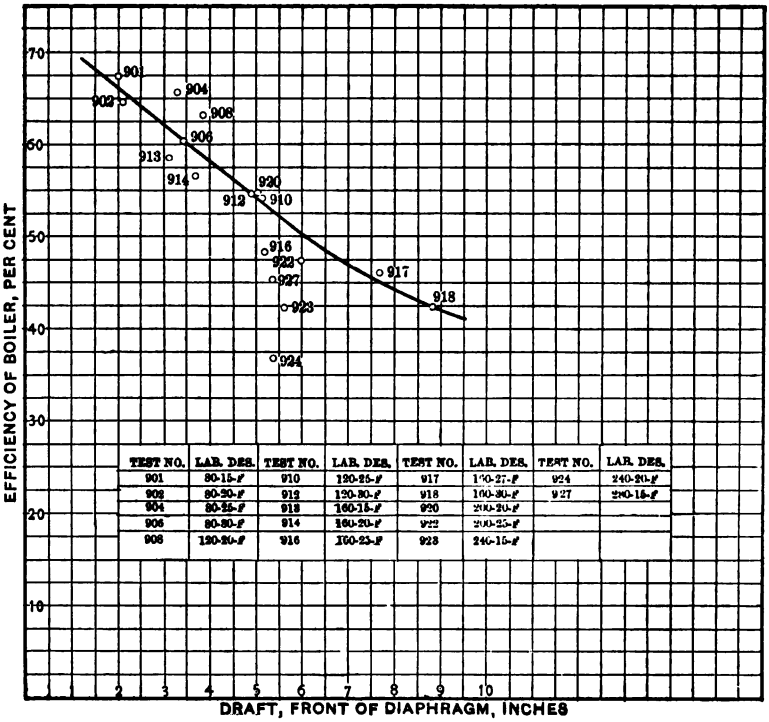
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 909.



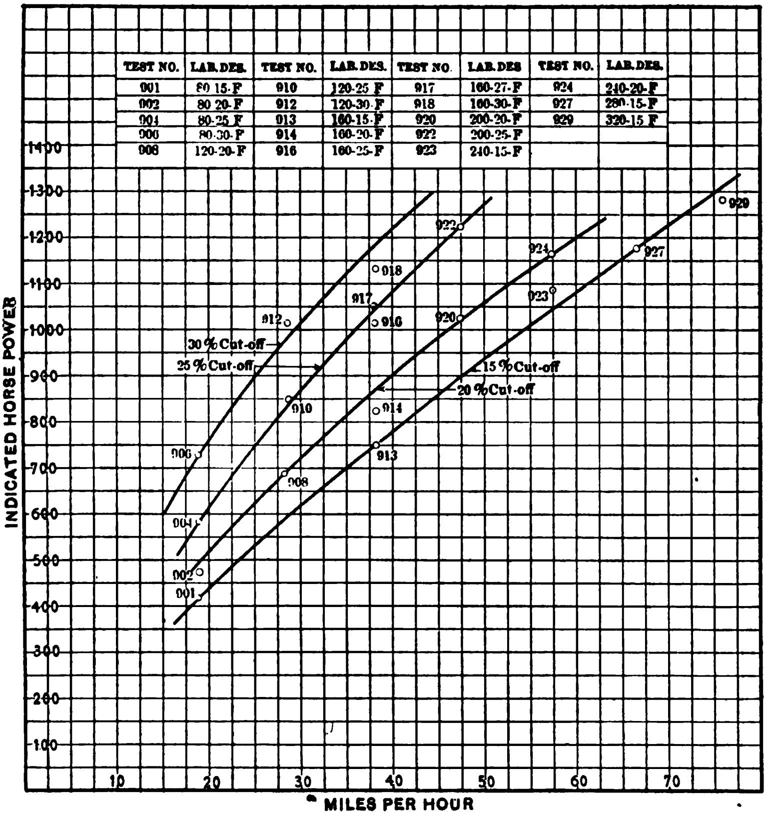
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	928	240-15-F		

PLOT No. 910.



TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

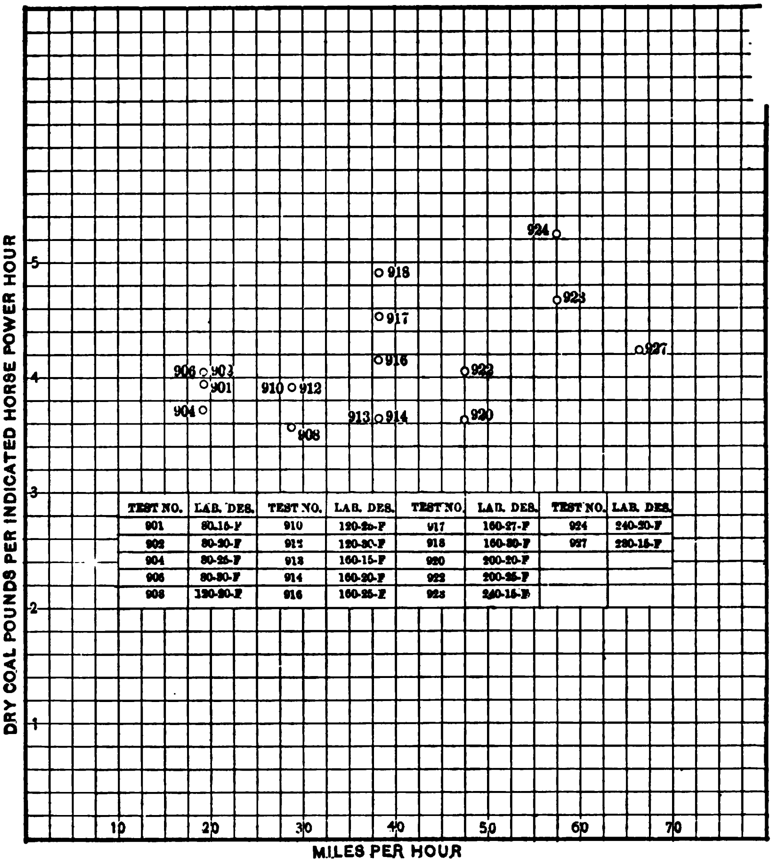
PLOT No. 911.



TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F	929	320-15-F
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

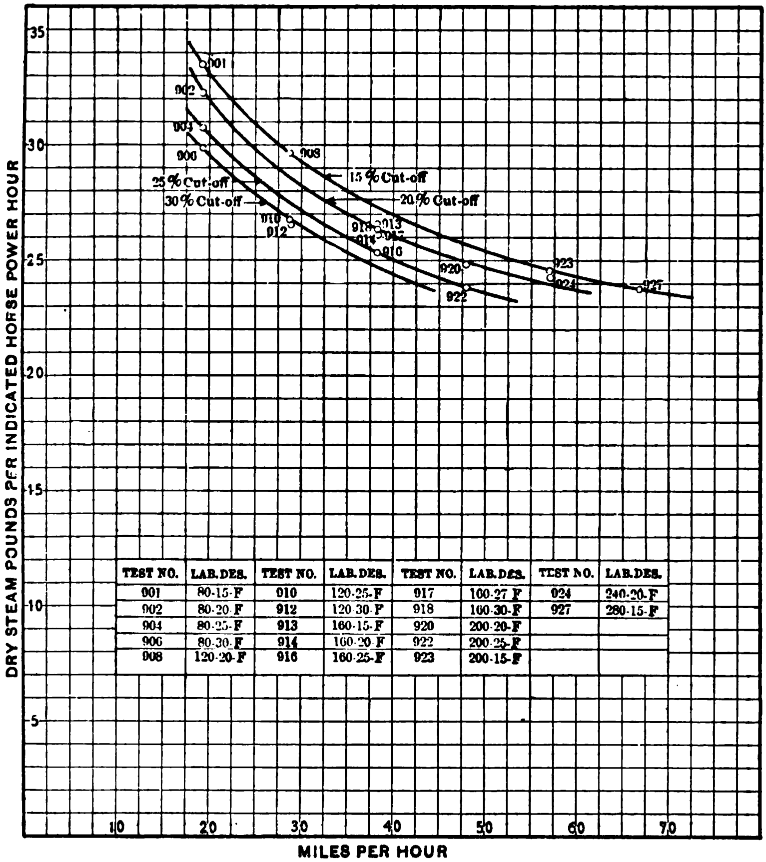
30 % Cut-off
25 % Cut-off
15 % Cut-off
20 % Cut-off
INDICATED HORSE POWER
MILES PER HOUR

PLOT No. 920.



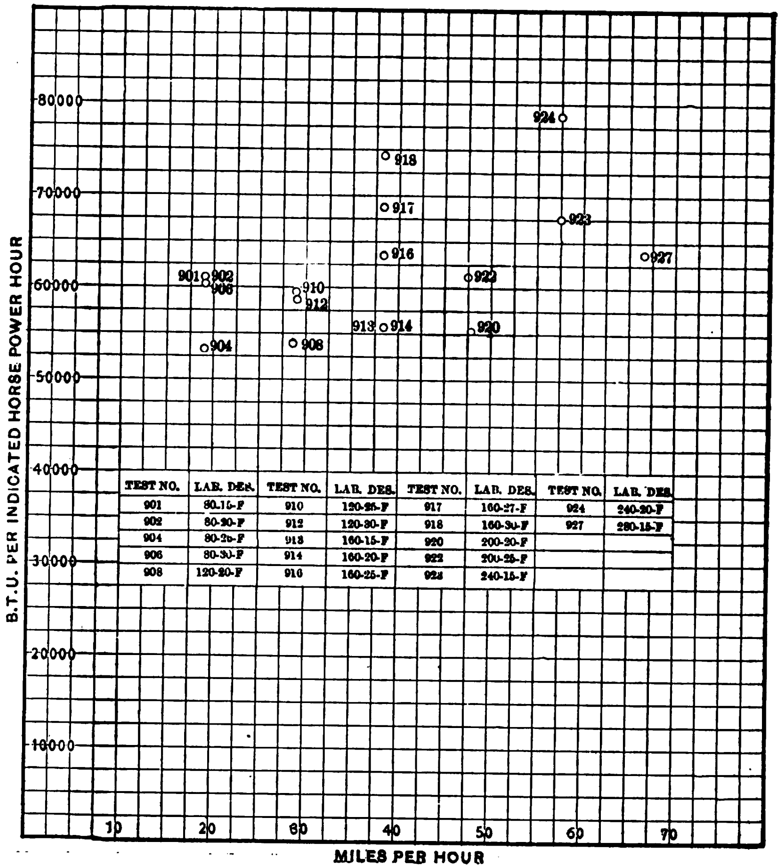
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 921.



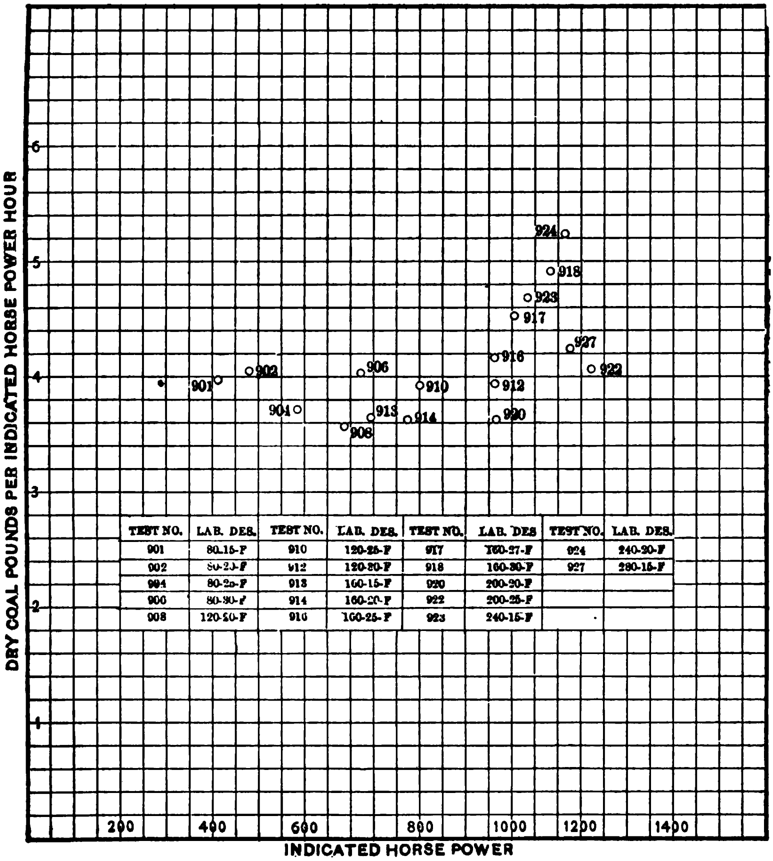
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	100-27 F	924	240-20-F
902	80-20-F	912	120-30-F	918	100-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	200-15-F		

PLOT No. 922.



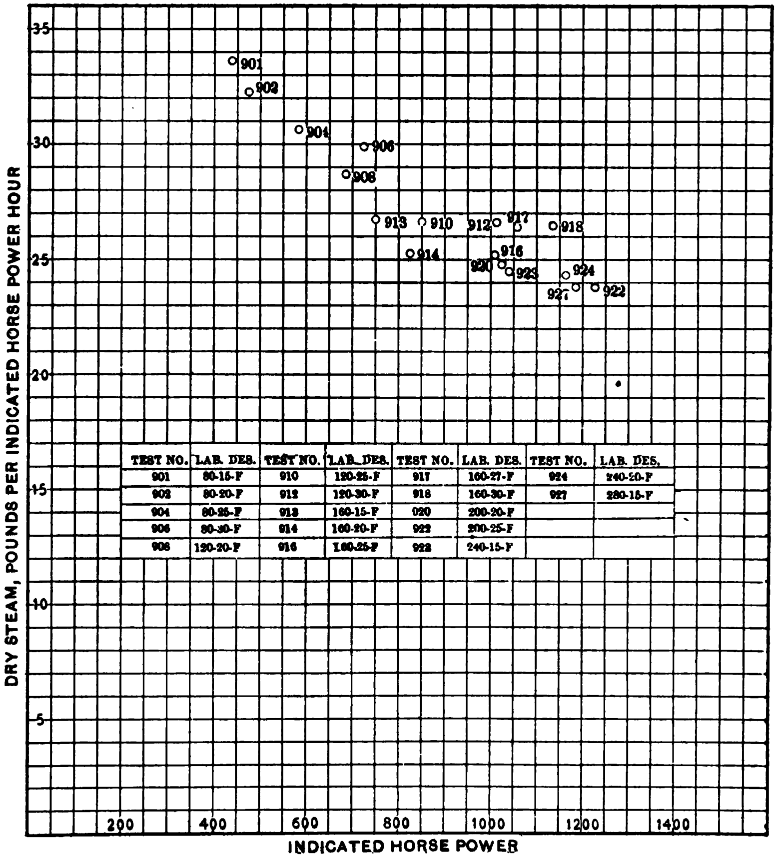
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 923.



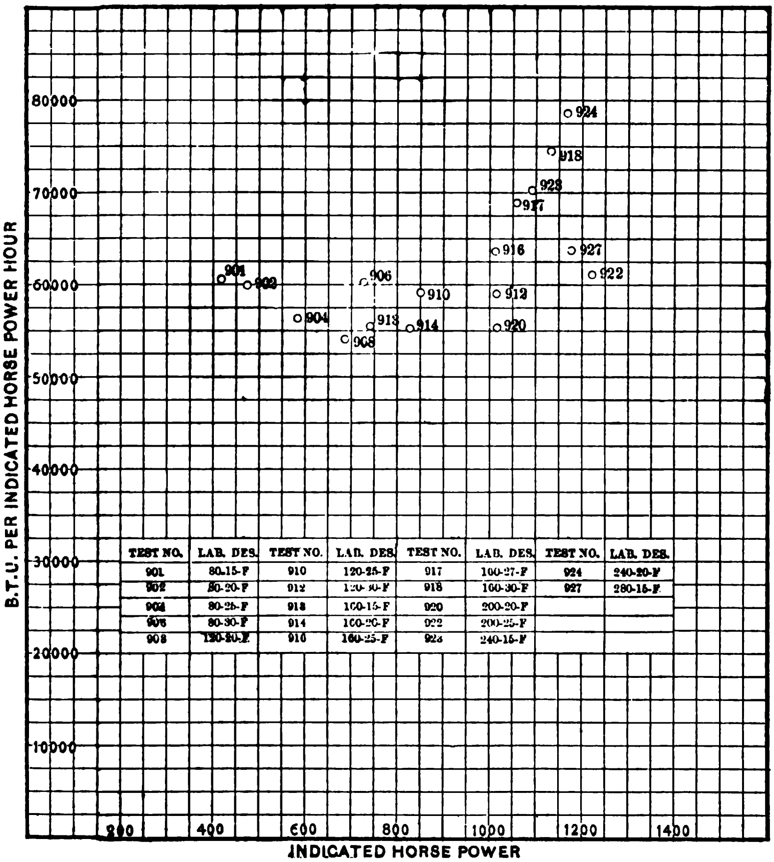
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 924.



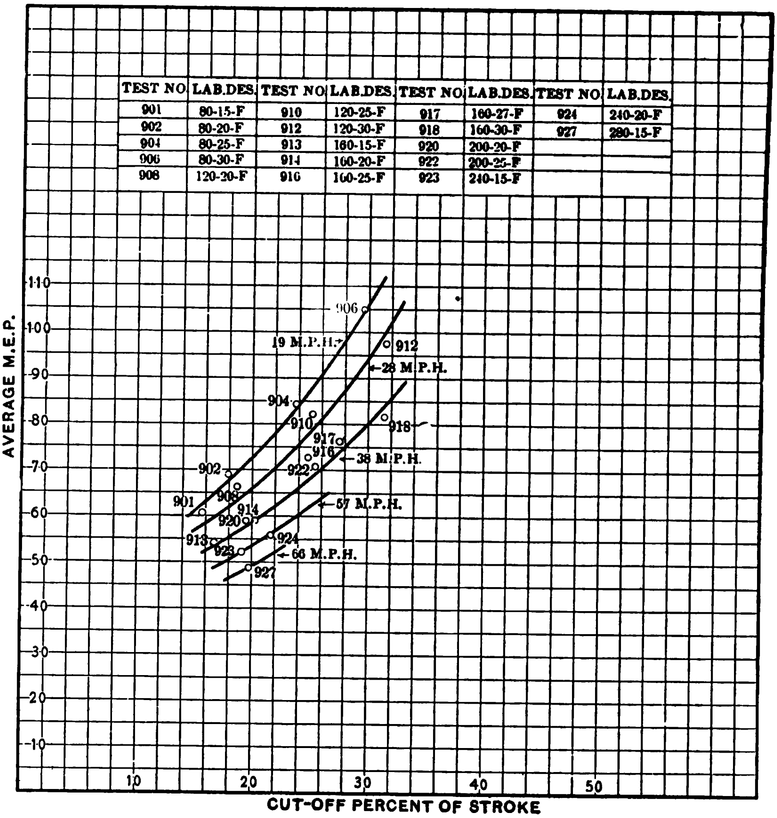
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	020	200-20-F		
906	80-30-F	914	100-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 925.



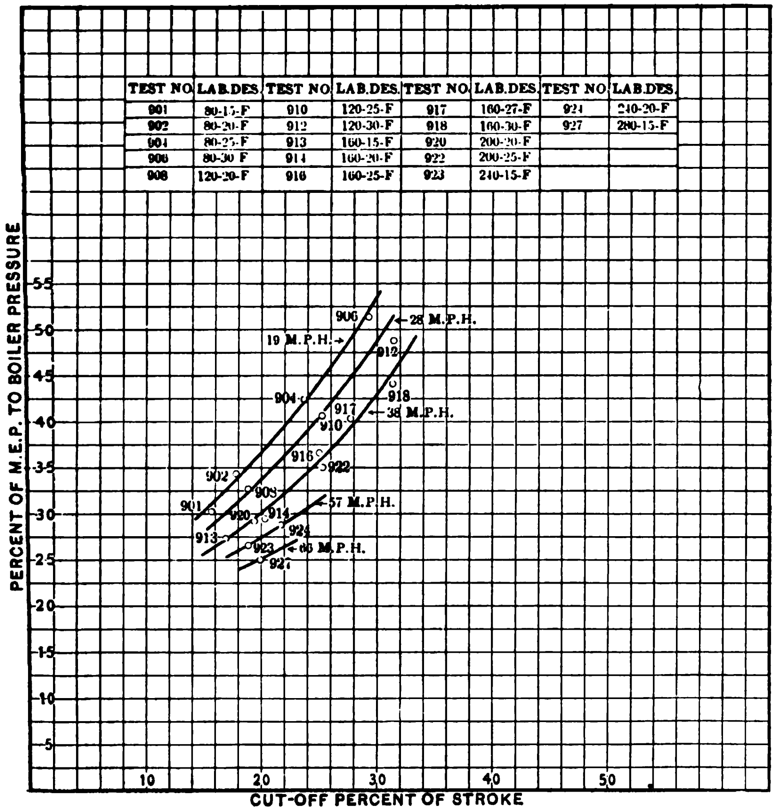
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 926.



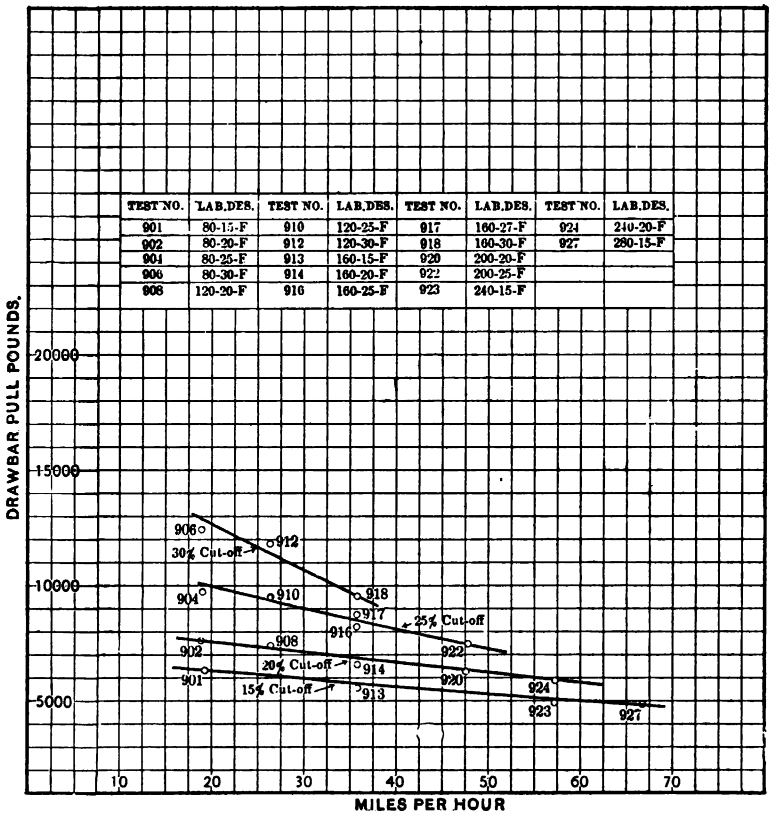
TEST NO	LAB.DES.	TEST NO	LAB.DES.	TEST NO	LAB.DES.	TEST NO	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 927.



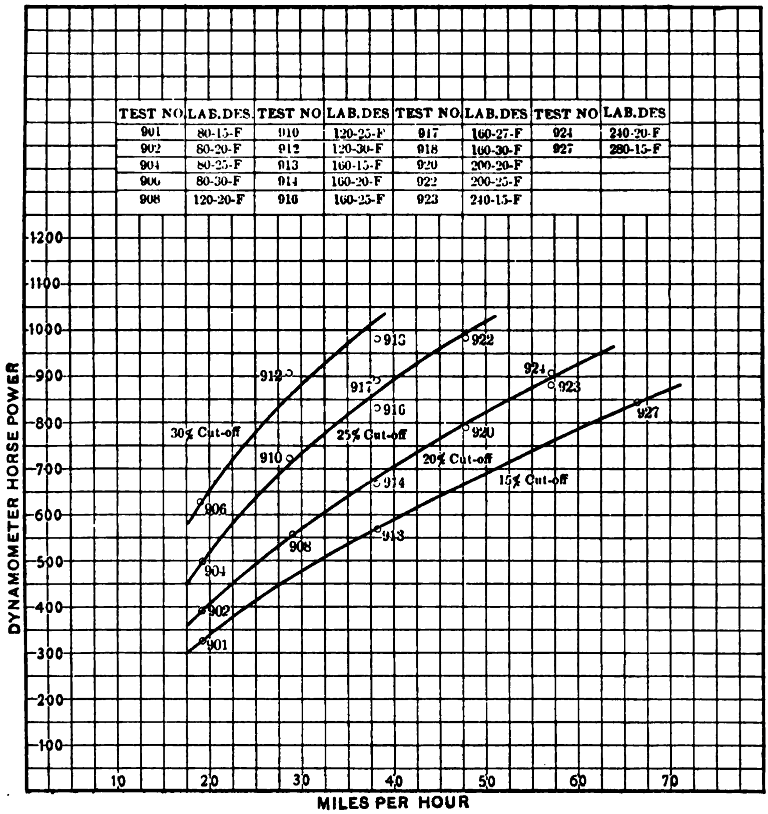
TEST NO	LAB.DES.	TEST NO	LAB.DES.	TEST NO	LAB.DES.	TEST NO	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30 F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 928.



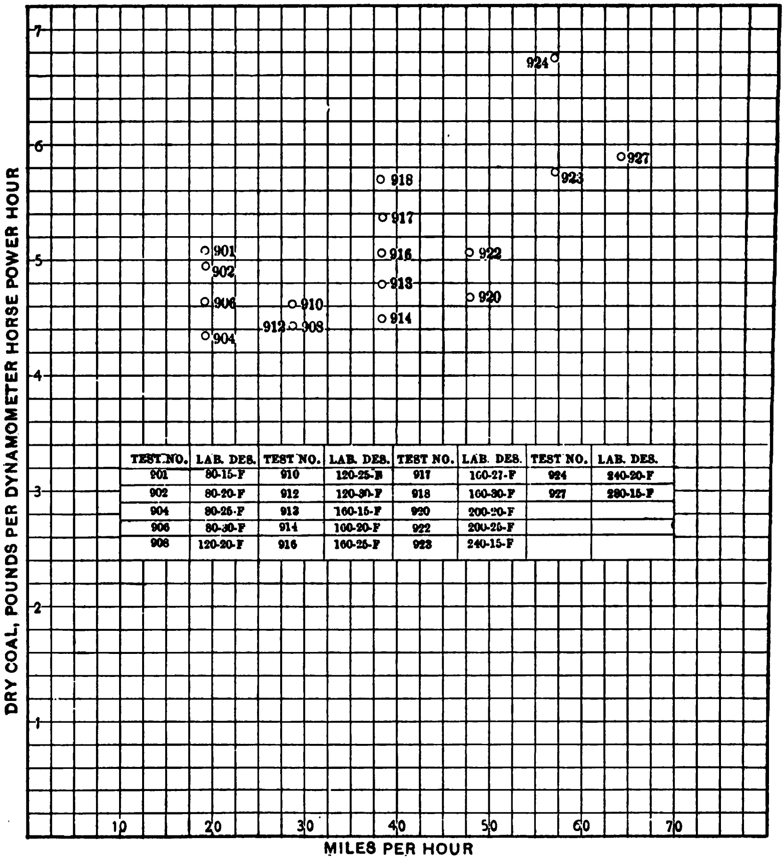
TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 940.



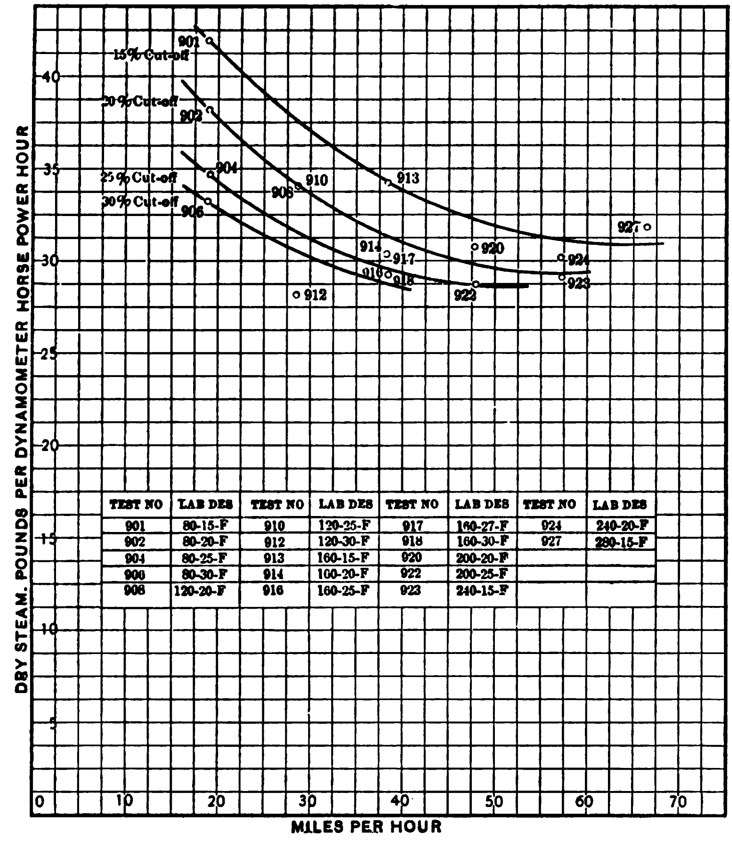
TEST NO	LAB.DES.	TEST NO	LAB.DES	TEST NO	LAB.DES	TEST NO	LAB.DES
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 941.



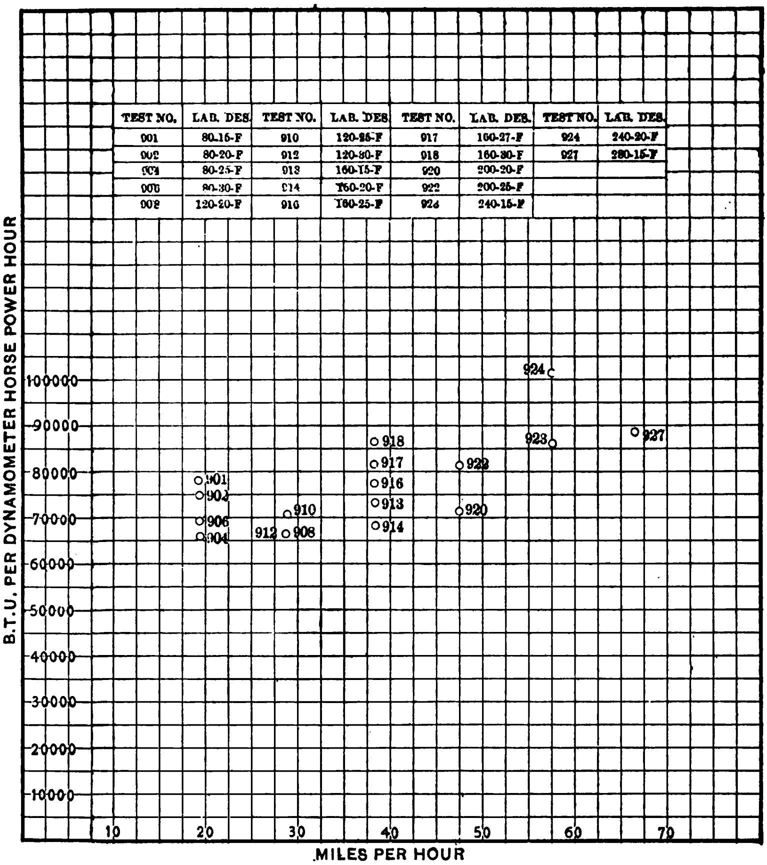
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 942.



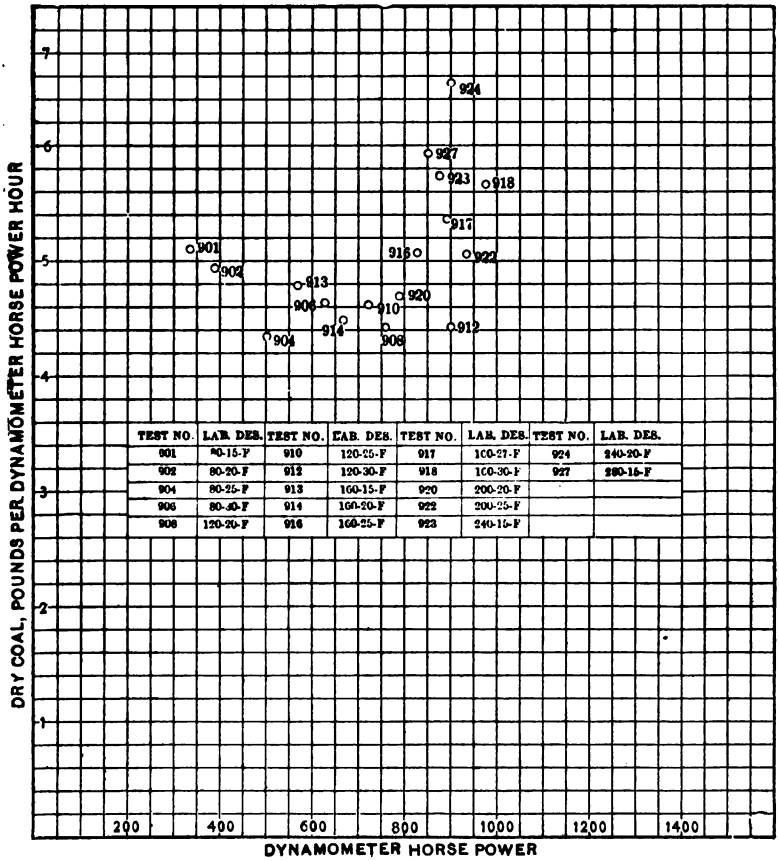
TEST NO	LAB DES	TEST NO	LAB DES	TEST NO	LAB DES	TEST NO	LAB DES
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 943.



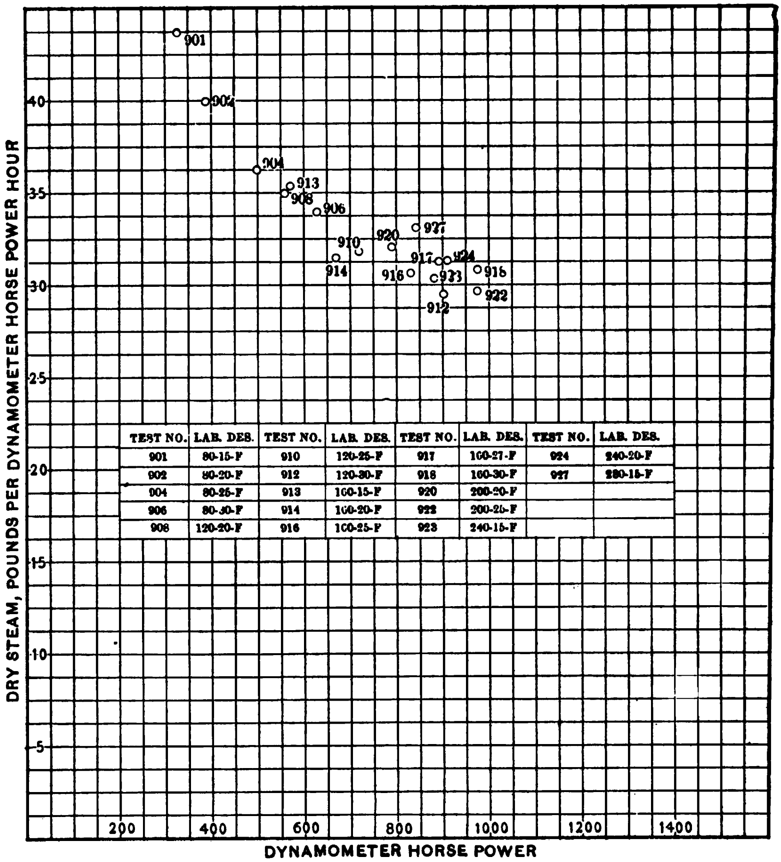
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 944.



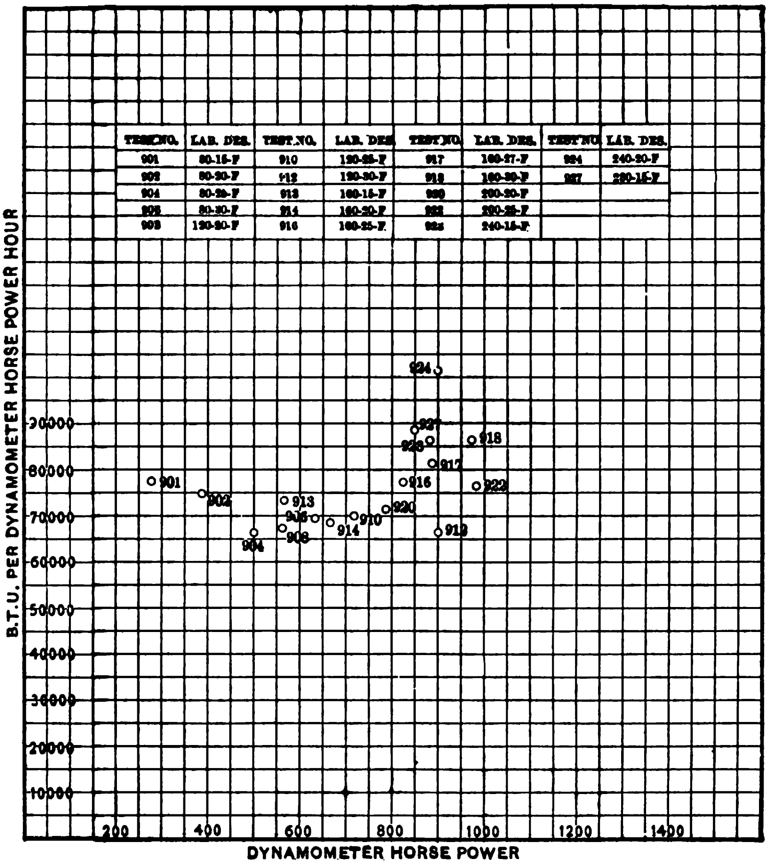
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 945.



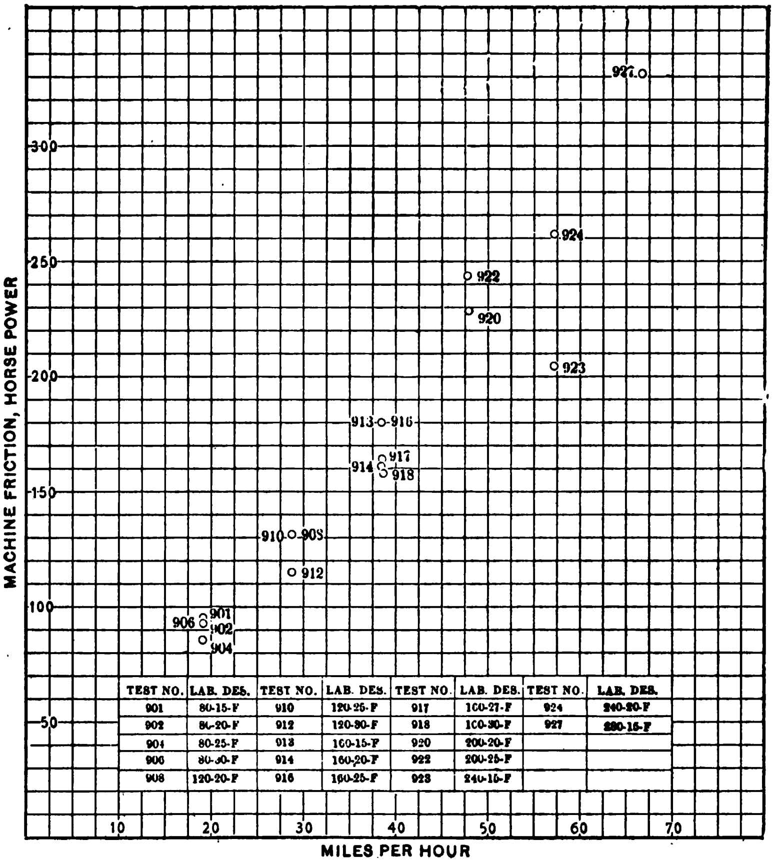
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 946.



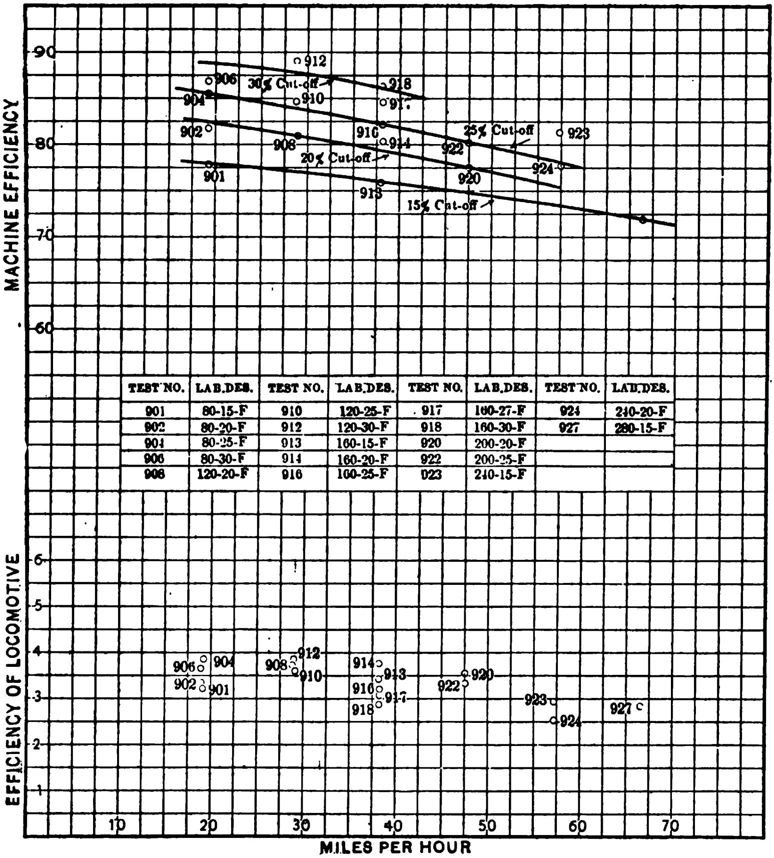
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
905	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F.	923	240-15-F.		

PLOT No. 947.



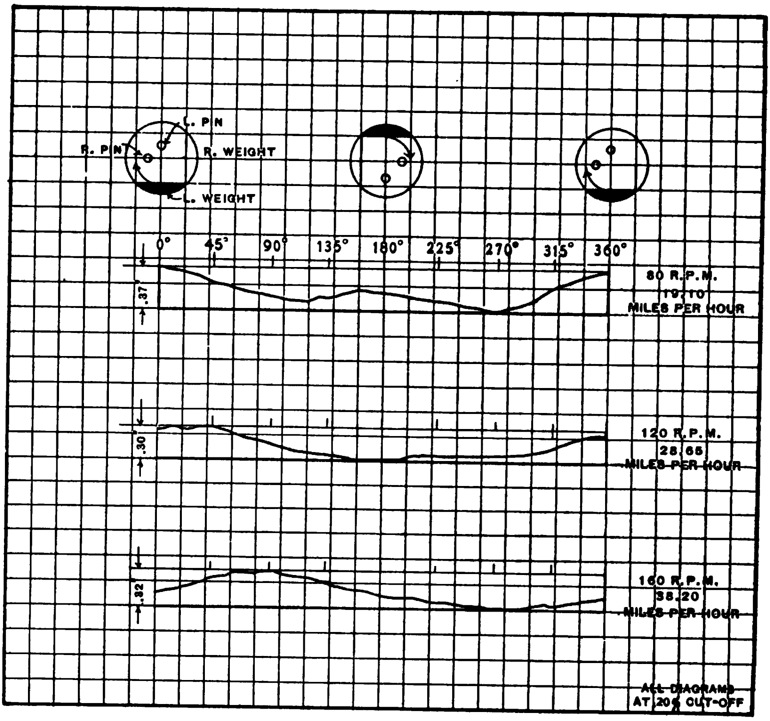
TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.	TEST NO.	LAB. DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

PLOT No. 948.

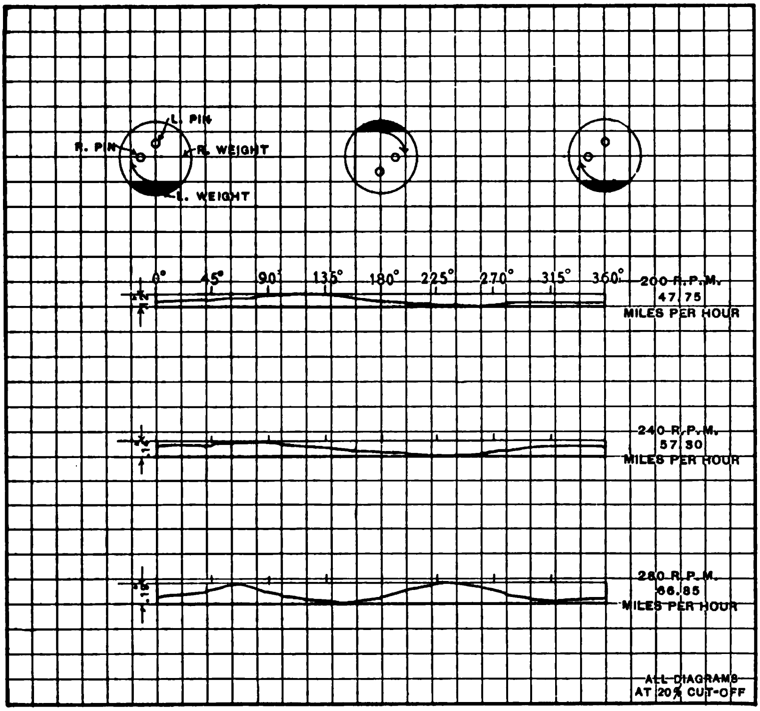


TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.	TEST NO.	LAB.DES.
901	80-15-F	910	120-25-F	917	160-27-F	924	240-20-F
902	80-20-F	912	120-30-F	918	160-30-F	927	280-15-F
904	80-25-F	913	160-15-F	920	200-20-F		
906	80-30-F	914	160-20-F	922	200-25-F		
908	120-20-F	916	160-25-F	923	240-15-F		

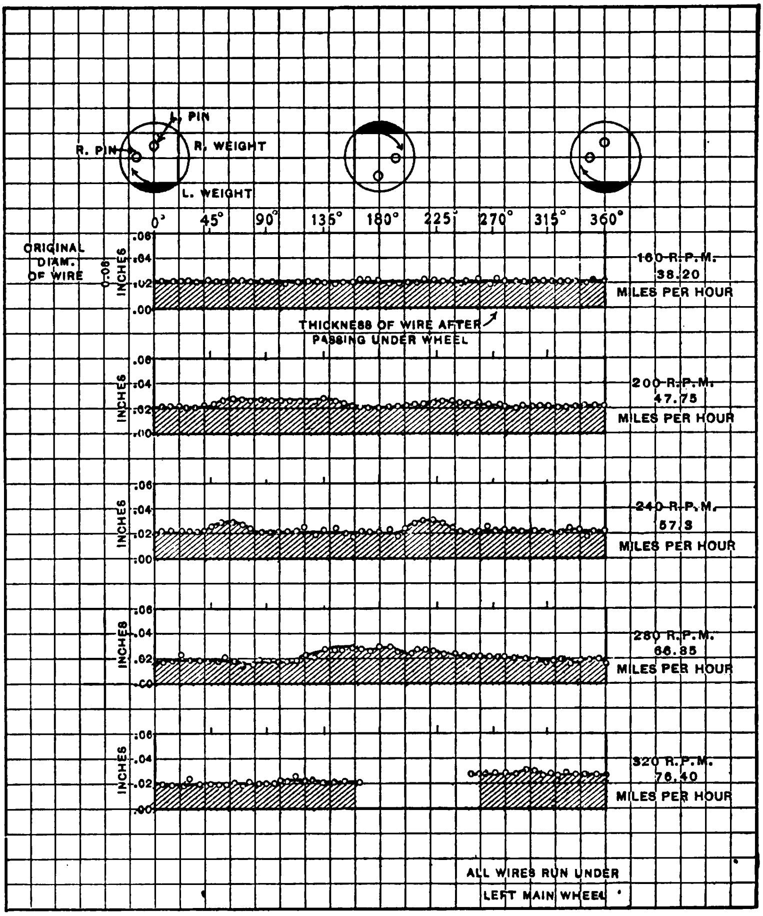
PLOT No. 949.



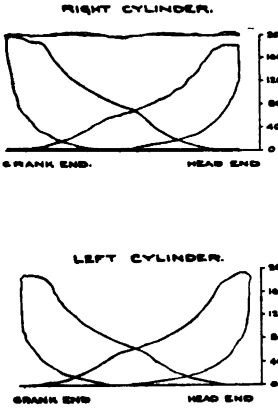
NOSING DIAGRAMS.



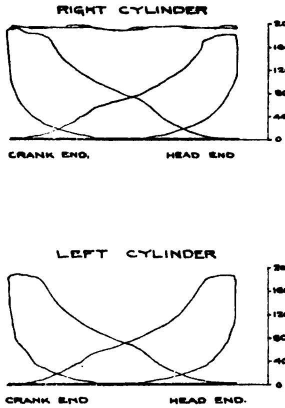
NOSING DIAGRAMS.



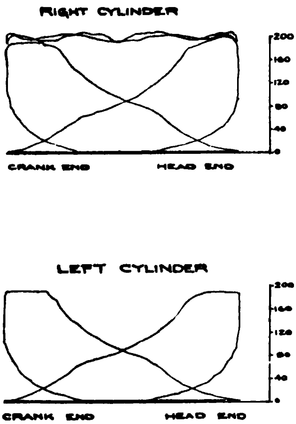
WIRE DIAGRAMS, COUNTERBALANCE TESTS.



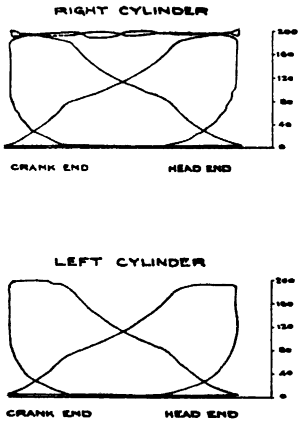
TEST No. 901 80-15-F
19.1 MILES PER HOUR.



TEST No. 902 80-20-F
19.1 MILES PER HOUR.

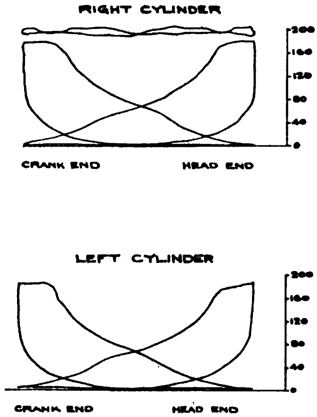


TEST No. 904 80-25-F
19.1 MILES PER HOUR

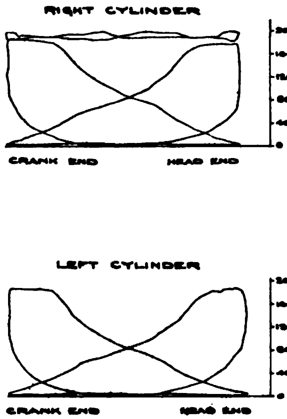


TEST No. 906 80-30-F
19.1 MILES PER HOUR

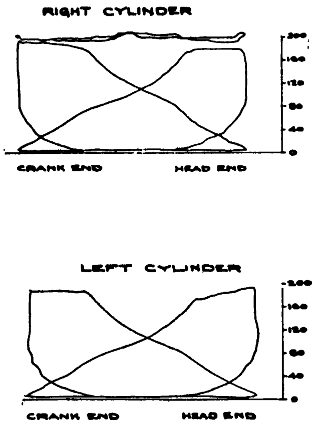
TYPICAL INDICATOR DIAGRAMS.



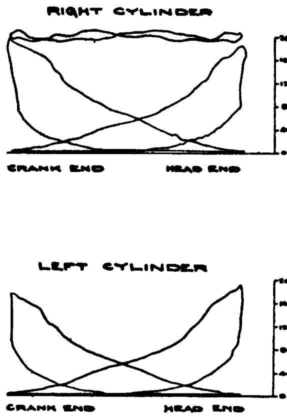
TEST No. 908 120-20-F
28.65 MILES PER HOUR



TEST No. 910 120-25-F
28.65 MILES PER HOUR

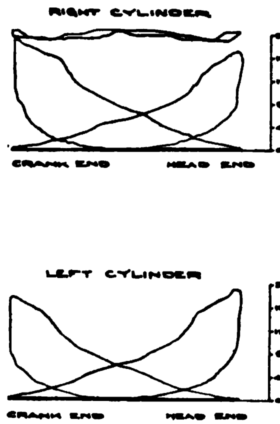


TEST No. 912 120-30-F
28.65 MILES PER HOUR

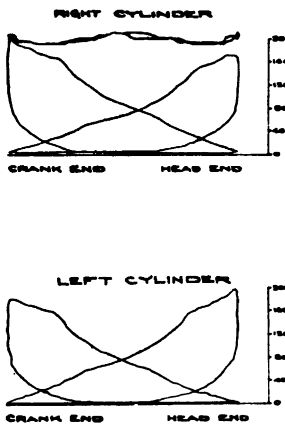


TEST No. 913 160-15-F
38.2 MILES PER HOUR

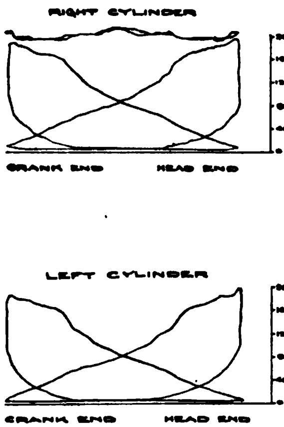
TYPICAL INDICATOR DIAGRAMS.



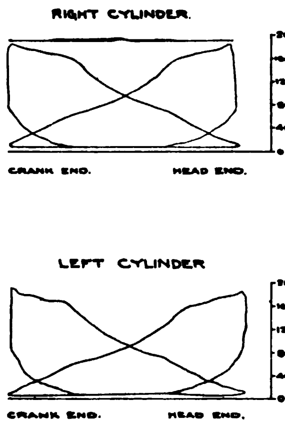
TEST No. 914 160-20-F
38.2 MILES PER HOUR



TEST No. 916 160-25-F
38.2 MILES PER HOUR

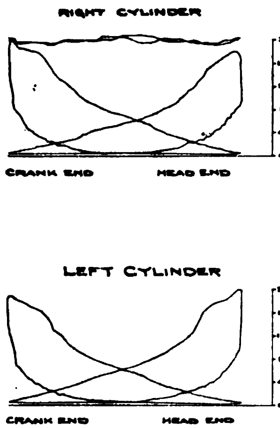


TEST No. 917 160-27-F.
38.2 MILES PER HOUR.

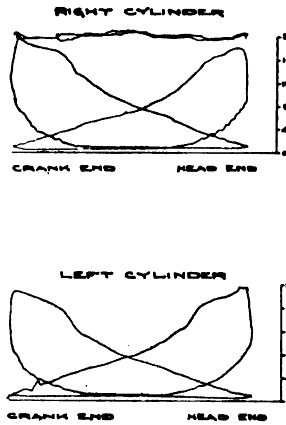


TEST No. 918 160-30-F
38.2 MILES PER HOUR.

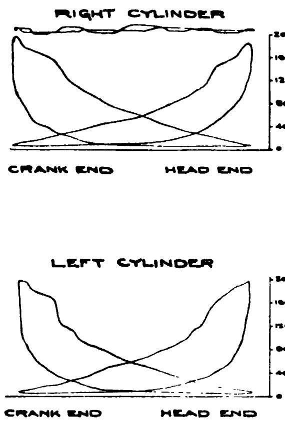
TYPICAL INDICATOR DIAGRAMS.



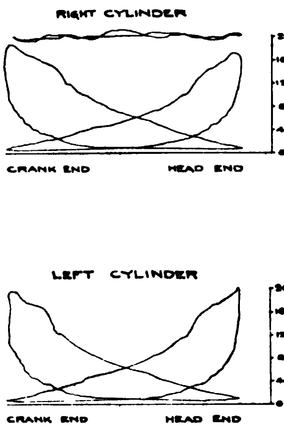
TEST No. 920. 200-20-F.
47.75 MILES PER HOUR



TEST No. 922 200-25-F
47.75 MILES PER HOUR

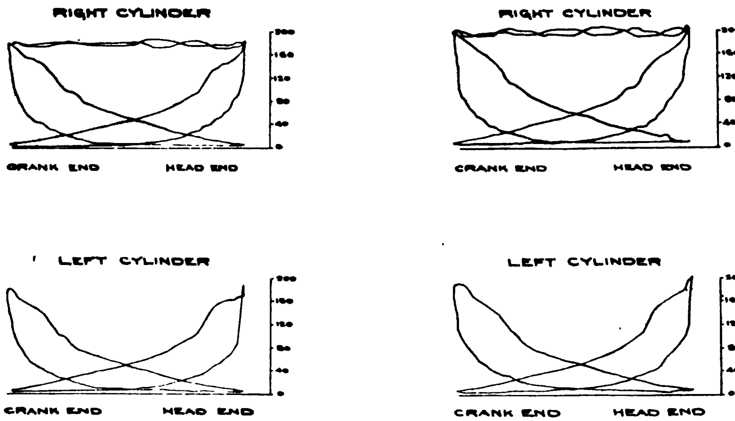


TEST No. 923 240-15-F
57.3 MILES PER HOUR



TEST No. 924 240-20-F.
57.3 MILES PER HOUR.

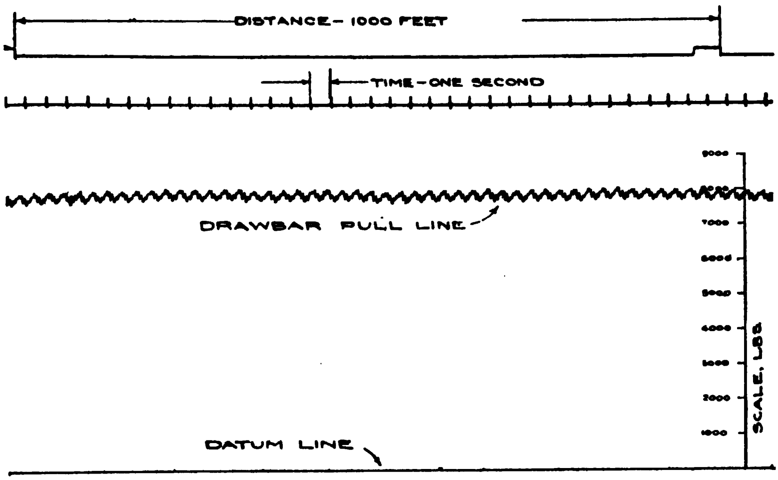
TYPICAL INDICATOR DIAGRAMS.



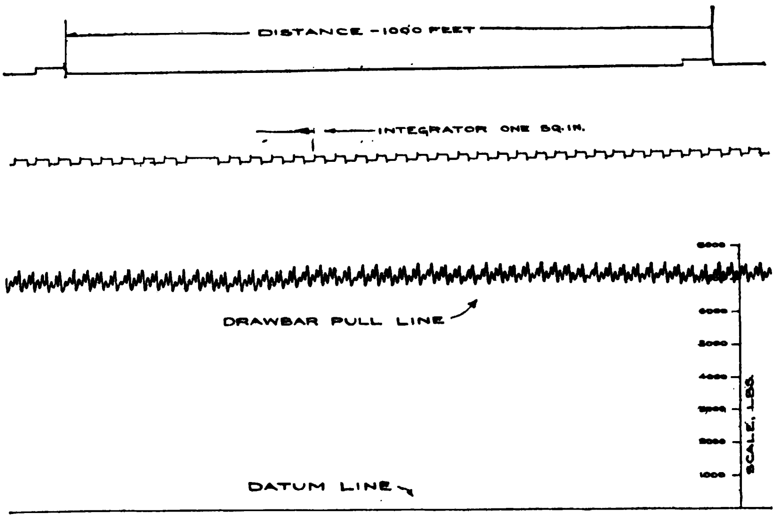
TEST No. 927 280-15-F
66.85 MILES PER HOUR

TEST No. 929 320-15-F
76.04 MILES PER HOUR

TYPICAL INDICATOR DIAGRAMS.

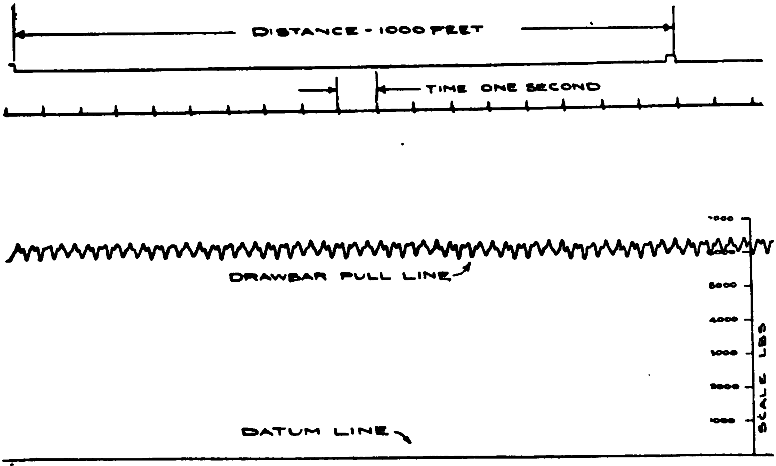


TEST No. 902 LAB. DESIG. 80-20-F

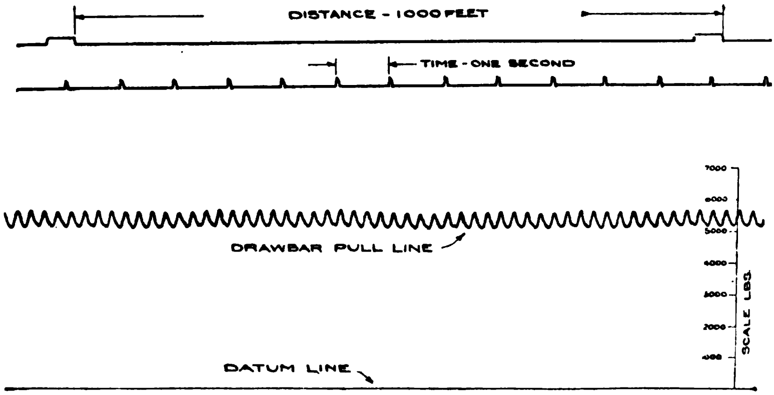


TEST No. 906 LAB. DES. 120-20-F

TYPICAL DYNAMOMETER DIAGRAMS.

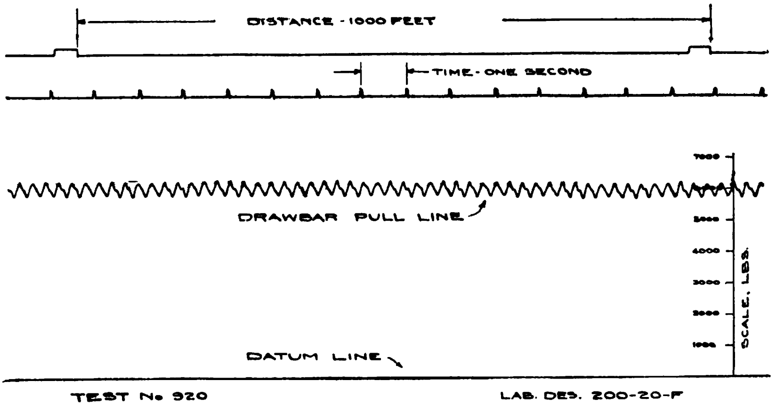


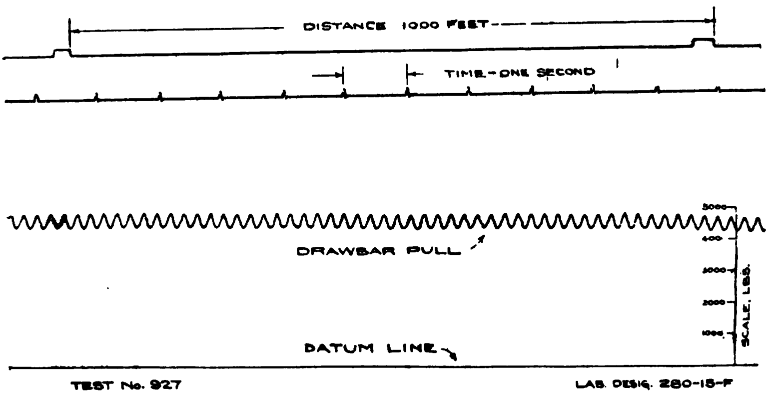
TEST No. 914 LAB DES. 160-20-F



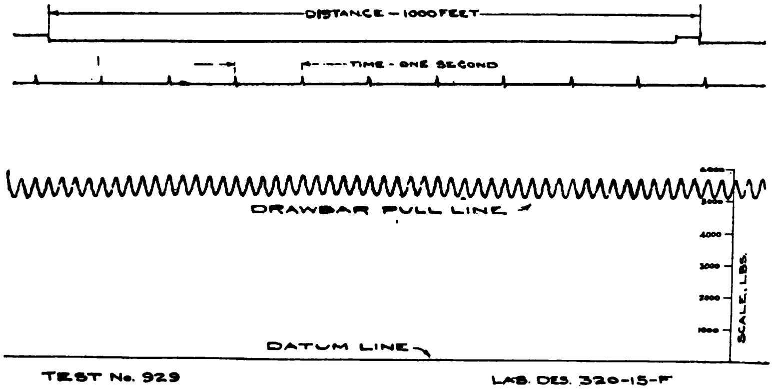
TEST No. 924 LAB. DESIG. 240-20-F

TYPICAL DYNAMOMETER DIAGRAMS.





TYPICAL DYNAMOMETER DIAGRAMS.



TYPICAL DYNAMOMETER DIAGRAMS.